A Critique Of Some Technical Aspects of Civil Defense

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National Academy of Engineering
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A Critique Of Some Technical Aspects of Civil Defense

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Prepared for:

Director, Office of Civil Defense

By the:

National Research Council. Advisory Committee on Civil Defense
National Academy of Sciences
Washington, D. C.

P R E F A C E

This report of the Advisory Committee on Civil Defense is in response to a request from the Director of the Office of Civil Defense for an independent statement on the technical status of civil defense. It is also responsive to the terms of the contract between the National Academy of Sciences and the Office of Civil Defense, which calls for advice and recommendations on technical factors involved in civil-defense problems. It puts into a single document a wide variety of topics which have been discussed during the past three years in meetings of subcommittees of the Advisory Committee on Civil Defense.

The subcommittees which have constituted the operating groups of the Advisory Committee have assignments in special areas: radiation shielding, blast and thermal effects, fallout phenomenology, protective construction, operations of a civil-defense organization, and the relationships of civil-defense systems with other damage-limiting systems. Mostly, these subcommittees examined technical questions within the assigned subject field; this report is an effort of the whole Committee to view the subtopics in the context of larger civil-defense problems. As such, it is incomplete, simply because the subcommittees do not completely cover the technical side of civil defense. Three important areas are not represented by subcommittees: medical and biological problems, postattack recuperability, and shelter habitability.* However, existing subcommittees overlap some of these areas; also, individuals with special competence in these areas, who are members of existing subcommittees, have assisted with problems in these fields.**

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* There has also been no subcommittee concerned with protection against chemical or biological warfare.

** It should be noted that the NAS Committee on Emergency Planning has a major responsibility for advising on postattack recovery.

The report has been drafted by the Committee Chairman assisted by the Technical Director. Drafts have been circulated to all members, with successive drafts incorporating or reflecting comments on the one preceding. It did not seem reasonable to ask the approximately 50 members to take full authorship responsibility, that is, to stand behind every statement in the report. Rather, each member has been asked to endorse the report, with such endorsement defined as giving full approval for statements in areas within one's competence, having no strong objection to statements in other technical areas, and supporting the general tenor of the report.* A section giving the comments, reservations, and dissents of Committee members appears after Part III.

The scope of civil defense in the United States, according to the Federal Civil Defense Act of 1950, as amended, is the "protection of life and property in the United States from attack." The act further states that responsibility for civil defense "shall be vested jointly in the federal government and the several states and their political subdivisions," and the "federal government shall provide necessary direction, coordination, and guidance ..." Executive Order No. 10951 of 1961, as amended, states that the civil-defense functions of the Defense Department "shall include but not be limited to the development and execution" of programs for fallout shelters; for chemical, biological, and radiological defense; for warning, communications, monitoring; for help to state and local governments for postattack actions including continuity of government; and financial aid to states. The Department of Defense Directive No. 3025.90 of 1965 calls for a "strong posture of civil defense" that will "provide the American public with assurance required to meet ... [a deteriorating military situation] without panic, in an orderly fashion."

We have used these statements of U. S. civil-defense objectives as background for our evaluation of current efforts — research, development, engineering studies** — to <u>improve</u> today's civil-defense posture, but we have made no direct attempt to evaluate the U. S. civil-defense effort itself.

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* This procedure was not followed with the appendices.

** Note that throughout the report the term "research" includes development and engineering studies.

We recognize that there has been a reluctance in the top echelons of government, both legislative and executive, to support a civil-defense program which would go beyond a minimum effort.* Accordingly, our suggestions are intended to be relevant not only to a program in which federal support stays within a factor of three of the present level with only minor changes in national security policy, but also to a program which would provide a better basis for expansions of civil-defense protection. A full analysis of civil-defense effectiveness, either of the present effort or of much larger efforts, requires background studies not attempted by the Committee.

The report begins with a summary statement of conclusions and recommendations and then proceeds in Part I to discussions of civil-defense operations and related shelter programs. In Part II, many of the basic research areas and problems are sketched, with specific technical recommendations included. Part III gives a sketch of the history of civil defense, taken largely from records of Congressional Hearings on the subject, and looks at civil defense as a total system. Appendix I gives supplementary material on foreign civil-defense activities. The other Appendices summarize in detail the results of the subcommittee discussions.

Lewis V. Spencer
Chairman

Richard Park
Technical Director

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* For a very recent statement on national civil-defense policy, see Executive Order No. 11490 published in the Federal Register, October 30, 1969.

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The various subcommittees of the Advisory Committee on Civil Defense agree that changes in the national civil-defense policy are required if substantial improvement is to be achieved in the U. S. capability to protect the population in the event of a nuclear attack and to recover from such an attack. Implementation of such changes need not wait on new research results, although research is essential to maximize effectiveness and reduce the cost of programs which would implement new policy. Furthermore, we believe that the present very restricted national civil-defense policy will continue to lead to reduction in the depth and scope of civil-defense research, whereas an increase in such research is required both to support existing programs and to prepare for an adoption of future policy of much broader scope.

With regard to research emphasis, we disagree with the policy of putting most of the research effort on "improving the capability for estimating cost-effectiveness and feasibility of alternative civil-defense programs of the future."* Instead we think that at least as much emphasis should be put on developments for new programs and for capabilities for rapidly and effectively implementing them as in estimating their cost-effectiveness.

We have concluded that the OCD research on shelters is appropriately and efficiently supporting the currently approved operational programs, i.e., protection from fallout. We also believe that research is providing inputs to the studies and evaluations of alternative future civil-defense programs. We do not, however, believe that current research is leading to a satisfactory growth in the actual capability for protection against prompt-effects of fire, or for crisis actions, or for construction of shelter, particularly under imminent threat.

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* OCD Research Progress Report, 1 April 1969. The report also states that the three basic programs of the future under study include, in addition to improving fallout protection, the provision of protection for urban populations against direct attack and of "systems designed to alter the vulnerability of populations and resources by action taken during a period of deteriorating international relations."

We contend that technical developments to support these broader future civil-defense capabilities need feedback at least from prototype efforts and that the organizational and instructional efforts that are required to make a civil-defense system complete and operational are also being unduly handicapped by the official, federal position that there should be little encouragement to the public to develop capabilities to protect against prompt-effects or fire.

Conclusions and recommendations on specific technical matters are in the body of the report. However, our major recommendations, which follow below, deal with policy changes and indicate, in broad outline, the direction of a research program which is aimed at a capability for rapid implementation of future policy changes. We believe that implementation of these policy changes would make civil defense more responsive to the threat, more consistent with our potential as a nation to provide civil protection, and more capable of recovering from any nuclear disaster. Hence, we urge consideration for these changes as part of a continuing buildup of civil-protection potential.

1. The federal policy on protection against the effects of nuclear attack should be changed to include prompt effects and fire as well as fallout,* and should reflect the varying degrees of local risk.

Since 1958, the United States has followed a fallout-only protection policy in its civil-defense activity, e.g., its surveys and its information and education efforts. Presumably, a protection system based on this policy would provide the most survivors-added per dollar spent, at least for the first few hundreds of millions of dollars, and provided that most of the weapons were ground-burst.

The United States has never financed public shelter construction nor the modification of buildings to make them suitable for shelter, nor has it offered financial inducements to encourage private con-

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* We group nuclear phenomena and effects into three categories: 1) those that occur in the first two or three minutes, i.e., prompt effects: gamma and neutron radiation, and the thermal and pressure pulses; 2) the fire effects, i.e., the coalescence of small ignitions into large fires; and 3) the fallout gamma and beta radiations. These latter two we refer to as delayed hazards: fire might develop and continue for time periods on the order of hours; fallout is an acute hazard for days and weeks.

struction of shelter.* Thus, federal civil defense has a double limitation: first, that only the fallout threat is countered, and, second, that federal activities are restricted to surveys, shelter stocking, shelter-utilization planning, and advising and informing the public on the threat and on possible civil-defense countermeasures. We believe that civil-defense countermeasures should reflect the prompt effects and the fire hazards of nuclear attack; that they should take account of the varying degrees of local risk, and that important progress is possible without a great increase in expense. We believe that the credibility of the civil-defense effort as well as of the preparations of the federal government for a postattack period would be substantially increased if surveys and shelter planning, as well as education and information material, indicated that the federal government is concerned with protecting against the full range of nuclear threats.

In this connection, it is very important that steps be taken to eliminate unnecessary security classification, and to assure the availability of hypothetical-attack studies to the technical lay public, particularly those studies containing information on the local risk.

2. The OCD should prepare guides for the analysis and design of structures to protect against prompt effects and fires, as well as fallout, taking account of relationships among the hazards, and using protection against injury as a criterion for shelter effectiveness.

There has been a tendency on the part of many people to view protection against prompt effects and fire solely from the point of view of blast shelters of heavy underground-construction type. While the importance of this type of design is unquestioned, it is actually one of several components in a far more flexible spectrum of protection. Also considered should be survey and slanting actions** that parallel those being followed in fallout protection; these efforts

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* See section on Comments, Reservations, and Dissents of Committee Members.

** "Slanting" is a term for changing designs to increase protective capability at an additional cost of almost nothing for fallout spaces, and something like $5/ft² for low-psi protection.

require suitable protection criteria for shelters in different localities to take account of hazard variabilities. In this connection, two types of criteria should be distinguished: those which identify different shelter categories and those which relate specific categories to local hazards.

With regard to the former, the Committee recommends that OCD use a minimum-injury criterion instead of depending solely on criteria for death or incapacitation. For the local hazard, protective construction must take greater cognizance of relationships between prompt and delayed effects.

3. Civil-defense research and other programs should be directed toward integrating civil defense, from the local to the national level, into the peacetime structure for dealing with all types of emergencies.* The OCD should take a more aggressive stance in encouraging action in this direction.

A civil-defense organization that incorporates appropriate local officials and is called on routinely to operate in peacetime emergencies will, we believe, perform far better in a nuclear disaster than if it had been consistently isolated from the rest of local-government operations. Moreover, frequent utilization of a civil-defense organization in peacetime or nonmilitary crises may stimulate greater public participation in civil-defense operations. It is therefore extremely important that the federal government encourage and assist local civil-defense organizations to integrate their activities into the routine structure and functioning of local governments.

Recent events clearly reaffirm the conclusion that local civil-defense operating centers, too, can provide an extremely useful and often unique assistance to local officials responsible for dealing with emergencies. This type of contribution by local civil-defense organizations is by no means nationwide, however. In many nonmilitary emergencies, civil-defense services have neither been requested nor offered; indeed the basis for such actions is clearly stated in state and local legal codes as being only for acts of God. For civil disturbances and accident-caused disasters, the local codes are not very clear; the federal law limits OCD responsibility to "an attack upon the United States."

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* See section on Comments, Reservations, and Dissents of Committee Members.

This situation appears to indicate that the availability of a clearer statement of government policy, a sharper definition of the responsibilities of the OCD and the Office of Emergency Preparedness* (OEP), and vigorous efforts by OCD to encourage, advise, and assist local civil-defense organizations to react to nonmilitary emergencies, might reduce the variation in responses among state and local civil-defense directors to the opportunities to assist local governments in peacetime crises.

4. The federal government should provide funds for constructing pilot civil-defense systems that include all essential operational elements.

Both during and after construction, a few selected pilot civil-defense systems, representative of U. S. geographic and population patterns, would be a source of feedback to research, to planning, and to training.

A major part of the pilot systems would be the shelter systems consisting of (1) dual-purpose shelters resulting from slanting the design of new construction, (2) modifications of existing structures, and (3) the outright construction of single-purpose shelters. We believe that the actual construction and modification of shelters is necessary for disclosing construction and modification problems, and for finding solutions to such problems; actual construction would also provide cost and construction-time data now unavailable.

A second essential operational element of the pilot systems would be the personnel to run them: to link together all their physical elements (e.g., the shelter system, the control system), and mobilize, organize, and train the required manpower. Operational problems could thereby be identified and attacked, and communications improved between the civil-defense "core" elements and the civil-defense "reserves," such as the National Guard.

Federal support, including indirect support such as a tax incentive, for the actual construction of shelters has been consistently withheld. Our recommendation is for a relaxation of that restriction so that the recommended pilot civil-defense systems may include both the single- and dual-purpose shelters that would have

* Formerly, Office of Emergency Planning.

to be constructed. In addition, we believe that a new look at the taboo against federal financial support of shelter construction seems to be warranted, not only because construction of the pilot systems would be a relatively inexpensive way to acquire considerable knowledge, otherwise unobtainable, but also because it must sooner or later be recognized that federal support, including financial, is a prerequisite for providing significant civil-defense protection for the public.

PART I.

RESEARCH, OPERATIONS AND FUTURE EXTENSIONS OF CIVIL DEFENSE

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OFFICE OF CIVIL DEFENSE (OCD) RESEARCH

According to OCD statements,[1] the general program objectives of OCD research are (1) partly to support currently approved programs, and (2) mostly "to improve the capability for estimating cost effectiveness and feasibility of alternative civil-defense programs of the future."

The statement also gives the basic types of future civil defense under study: "1) systems similar to the current civil-defense posture that offer substantial improvement yet lie within the general framework of present national security policy, 2) systems designed to provide a high degree of protection to urban populations against attacks directed against them, and 3) systems designed to alter the vulnerability of population and resources by actions taken during a period of deteriorating international relations."

In our view, the OCD research program provides efficient support to the current program for fallout protection and related programs contributing to current national security policy. It does emphasize systems evaluation from the point of view of cost and effectiveness of programs of the future. Much of this research is performed to yield data that will provide a better base for a decision-maker of the future to make decisions regarding policy on civil-defense posture.

But research directed toward the provision of information needed for systems evaluation, hypothetical attack studies, and other tools of the decision-maker does not necessarily or even usually produce data that are appropriate for design or analysis of actual civil-defense countermeasures. Furthermore, <u>evaluation</u> of possible new postures and countermeasures does not provide the sense of urgency and the feedback to research program management that might accrue from a program that had the explicit objective of developing a standby capability of <u>implementing</u> the more important types of policy extensions regarding civil-defense posture. In this connection, several factors must be considered:

1. In the absence of a crisis atmosphere, new civil-defense policies are unlikely to be declared unless it is fairly certain that they can be implemented and that procedures for implementing them are available.

2. An approach to policy decision on future civil-defense postures through studies of hypothetical attacks gives some information about, but otherwise puts no premium on, desirable and readily attainable extensions of policy.

3. In the past, new civil-defense policies have often evolved in an atmosphere of possible crisis.

4. In a crisis, the need for rapid developments is apt to make the optimization of cost-effectiveness become much less important, and the implementation of countermeasures must be immediate.

The question we have been most concerned with is how well does OCD research perform in providing for protection beyond fallout-only, i.e., in developing techniques, procedures and equipment for actual countermeasures to other threats under all conditions of urgency -- gradual, rapid, or crisis.

In examining current technical civil-defense programs, we conclude that efforts to provide protection beyond fallout-only are not following the same pattern that was followed in the development of fallout protection, and, in comparison to the latter, are quite ineffective. This pattern consisted of announcing a federal policy for encouraging the construction of fallout shelters (1958), but without significant federal funding. However, there was federal funding of pilot surveys of existing buildings and for design and construction of shelter prototypes. With all their many faults, these two programs were indicative of an interest and concern within the federal government that served to encourage and intensify further efforts to develop and improve survey procedures and shelter designs. It was clear that the feedback and sense of urgency generated by federally supported programs was a vital element in making an effective and rapid program to develop fallout protection. We stipulate that a similar attitude of encouragement, generated by federal support on prototype design, on surveys, and on public instruction, would result in a similarly successful program for developing protection against prompt effects and fire.

At present the federal government is not sponsoring such work; rather it takes the position of no federal encouragement of prompt-effects and fire protection. This attitude has some logical support because of financial and manpower limitations, but it should be emphasized that it results in (1) a research program not oriented towards producing a state of readiness to implement new civil-protection requirements, and (2) some skepticism concerning the realism, and sometimes the candidness, of the present federal approach to civil defense.

Almost the same arguments apply to civil-defense operations. We feel that a more realistic research program in support of emergency operations -- e.g., mobilization of manpower, control facilities and procedures, plans for crisis actions, etc. -- would result from relaxation of current policy on fallout-only protection as well as from more aggressive OCD support of local civil-defense involvement with non-nuclear-war

emergencies. The aim of such research should be to support the development and enhancement of an in-being state of operational readiness at all levels of the civil-defense structure from the local to the national.

CIVIL-DEFENSE OPERATIONS

The dependence of civil-defense research on policies established outside of OCD has been alluded to. Accordingly, we first discuss the U. S. approach to civil defense, beginning with an outline of the division of authority for civil-defense plans and operations in the federal government.

The Division of Authority.

Planning responsibilities are divided between the Office of Emergency Preparedness and the Office of Civil Defense. The former is assigned planning responsibility for postattack recovery; the latter is assigned responsibility for planning various countermeasures for the attack period, and for the shelter and damage-limiting period immediately following the attack.

Responsibility for actuating and implementing civil-defense operations locally is determined by local ordinance and state law. On a national basis, the only civil-defense operational mechanisms which exist are intelligence and communications mechanisms, i.e., attack-warning and damage-assessment communication channels. Authority for actuating these has been delegated by the President to the Department of Defense.

The regular military forces have been authorized to assist local or state civil-defense activities in emergencies, subject to decision by the appropriate military commander that such forces or equipment are not required for military assignments.[3] National Guard units are under the control of state governors unless and until they are federalized by presidential order and become part of the federal armed forces. Their potential use in civil defense is discussed briefly later. Training of military units in civil-defense operations has been authorized,[4] and some has taken place.

Initiative for planning, for research, and for advisory assistance to local civil-defense authorities in connection with nuclear-attack civil countermeasures thus rests with OCD. The initiative for establishing long-range objectives for civil defense, however, is shared by OCD with other levels of government, usually higher than OCD. Long-range objectives reflect the national policy for civil defense, a policy that is determined by economic, political, military and other considerations. Thus the planning for which OCD is responsible is confined within the limits set by the long-range objectives and national policy.

Civil-Defense Operations and Back-Up Studies.

In general, the OCD approach is first to encourage and assist in the production of various types of emergency resources, including trained people; and, second, to assist the local organization to tie these into a coordinated system, identifying components and resources by means of Local Civil-Defense Program Papers.[5] The main resources are Emergency Operating Centers (EOCs), emergency information networks, shelters, fire-fighting systems, medical personnel, police departments, other specialists, and instruments, plus people with some training in rescue operations, shelter management, radiation monitoring, etc. A major OCD contribution to local civil defense is the system of matching funds whereby federal money augments local funds, although these funds are not provided for shelter construction.

One type of local organizing activity is carried out through the Community Shelter Plan (CSP) for allocation of people to identified and stocked fallout-shelter spaces. Another is for development of additional fallout shelter through slanting of new construction as well as surveys. A third action is to assign responsibilities to various local authorities for the periods of preattack preparation, of attack, and of shelter occupancy and immediate postattack countermeasures.[5]

Contingencies which may be faced locally are identified as one or more of a set of nine Basic Operating Situations (BOS). These nine situations do not describe prompt effects -- the blast wave, the thermal pulse, the initial radiation -- but are concerned only with the delayed effects that follow. These delayed effects of fire and fallout may be negligible, moderate, or severe, totaling nine combinations.* Each locality is encouraged to develop plans in some detail for likely contingencies; in general, these plans are for: 1) evacuation in case of uncontrollable fires, 2) rescue, fire control, and repair for controllable fires to the extent permitted by fallout radiation, 3) shelter occupancy for moderate and severe fallout, and 4) in an essentially no-damage situation, the provision of assistance to other communities. The relationships between these nine delayed-effects situations, and their various possible combinations with prompt effects, are not included. To ensure that these plans are sound and that they are properly responsive to the threat requires an advisory capability which is probably not adequately provided for at present.

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* The nine combinations are: 1) Negligible fallout/negligible fire; 2) moderate fallout/negligible fire; 3) severe fallout/negligible fire; 4) negligible fallout/controllable fire; 5) moderate fallout/controllable fire; 6) severe fallout/controllable fire; 7) negligible fallout/uncontrollable fire; 8) moderate fallout/uncontrollable fire; 9) severe fallout/uncontrollable fire. Research now in progress may modify these categories.

To make the plans and operations more realistic, a series of studies has been contracted by OCD,[6] as follows:

1. The problem of attack warning, including both physical mechanisms and psychological requirements for informing and convincing the public.

2. Procedures and techniques for moving people to shelter, including the manpower requirement.

3. Procedures for shelter management.

4. Provisional solutions to shelter-deficit problems.

5. Radiological-monitoring requirements and techniques.

6. Rescue operations, including an estimation of the magnitude of the problem and the corresponding manpower requirement.

7. Local communications problems.

8. Maintenance of law and order.

9. Feasibility of remedial movement to safer locations.

10. Feasibility of a program of engineering and maintenance operations.

11. Requirements for an emergency welfare system.

All these developmental studies draw heavily on the research base, including the theoretical prototypes generated in the 5-Cities Study.*

Comments and Identification of Some Deficiencies.

As an advisory committee, we have the assignment of constructive criticism; and this means directing our efforts to identify the weaknesses and the deficiencies in such a program. Within the limitations imposed on current programs for civil-defense operations -- limitations of money, manpower, and policy -- it is apparent that the research program is coherent and thoughtfully constructed. We believe, however, that these limitations, particularly the fallout-only policy, are so severe that they dominate the situation. We also feel that these limitations, imposed on OCD by outside circumstances, may have been accepted too readily.

* Detailed expositions of hypothetical nuclear attacks on San Jose, Albuquerque, New Orleans, Providence, and Detroit. This OCD study is a continuing one.

At the time of an attack, people are requested to move to the nearest fallout shelter, or, if time does not permit, to "duck" into the nearest "cover."[7] While this last is good advice, it also demands careful study of the possibilities of duck-and-cover, i.e., short-warning shelter. Information on availability, design, cost, and effectiveness of such shelter appears to be lacking.

More generally, neglect of prompt-effects is a most serious limitation. Instructions for local program papers[5] do not develop prompt-effects operational problems systematically; nearly the whole literature is on fallout protection, and pertains to survivors who are intuitively quick, removed from intense prompt effects by sufficient distance, or successful in finding adequate cover -- a characteristic not necessarily found in a fallout shelter. Furthermore, the current planning material deals with fire as a fire-control problem and not with the vulnerability of fallout shelters to fire.

Another limitation of OCD operational planning is its exclusive focus on nuclear disasters and its emphasis on developing capabilities to be used only for nuclear attack. This limitation can be reflected in the characteristics of the local civil-defense organization. Any local government, to be effective, must operate as a closely unified team. The local civil-defense system must be part of that team. It is not enough to have plans; the local civil-defense system must be used and found valuable for local emergencies if it is to function well under the extreme conditions of nuclear attack. This means that what OCD faces is the problem of unifying local emergency protection services of all types. To do this OCD must, in fact, be free to take cognizance of peacetime emergencies through the medium of literature, in training, in prototype systems, and quite possibly by some subsidization. But authority to do this is not, in fact, assigned by the Executive Orders to OCD, but to OEP.[2] There appears to be good cooperation between these agencies, but this division of federal authority presents a barrier to establishing organizations capable of functioning effectively in the event of nuclear war.

Other problems relate to fairly complex questions of manpower requirements and manpower availability. Existing forces for dealing with nonmilitary emergencies -- firemen, police, etc. -- are taken for granted as part or all of a functional "core" to which "reserves" can be attached if needed. But nuclear attack would demand a substantial fraction of a population in countermeasure activity; hence, these core forces are too small by perhaps as much as an order of magnitude.* Training of

* According to a preliminary estimate, six million trained people would be required to provide the minimum maintenance of essential services in the U. S. If we add the crisis mobilization requirements and compare these with the availability of regular and auxiliary safety and protective forces (including 184,000 trained volunteer reserve and police, 172,000 reserve firemen, 176,000 rescue personnel, some 100,000 shelter managers, and some 235,000 radiological monitors), it would appear -- on an *a priori* basis, at least -- that the actually trained and available manpower may be an order of magnitude short of the potential requirements.[8]

shelter managers and radiation monitors is occurring. But these people and the other core forces need to be given, in addition to training, at least semi-official status through identification with reserve units; they should be kept on a roster and periodically given additional training.

<u>Manpower Requirements</u>.

Regarding manpower requirements, there will always be two obvious questions: What are the requirements for a suitable standby core and what are the requirements for a suitable reserve? Answers to these questions surely depend on likely contingencies and on local circumstances. Further, the requirements must depend on the status of prompt effects and fire protection: Are there to be any organized countermeasures for prompt effects during an attack and for fire afterwards? Is there expected to be any large number of survivors in the region of intense prompt effects? If DOD writes off the possibility of surviving in regions of intense prompt effects or fire, manpower requirements are surely much less, both for core and reserve, unless preattack evacuation is successfully accomplished.

Some partial attempts to examine manpower requirements have been made, mainly for the total -- core plus reserve. We think that additional, more systematic attempts should be made for core and reserve separately. These should consider the problem and mechanisms of rapid expansion, the likely contingencies, and the special problems of duck-and-cover actions; they would sharpen an understanding of local civil-defense effectiveness at all levels of government.

<u>Availability of Trained Manpower</u>.

Obvious sources of trained manpower are fairly easy to list: standby community forces from fire and police departments, volunteers, National Guard, military reserves, and the regular military forces.*

But generally speaking, regular military forces give first priority to military assignments, they are not likely to be present and available at the place and moment of greatest need, and they are in a separate, military line of command. The Ready Reserves are subject to call into military duty. In a protracted emergency period, the Standby Reserves might also be called to duty; the National Guard can be federalized and taken from state control.

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* Other sources as yet unevaluated probably exist. For comments on use of military retirees in a civil-defense role, see section on Comments, Reservations, and Dissents of Committee Members.

Pursuing this line of analysis, one finds a depth of trained manpower available to the military; but there is, and will be, great resistance to assigning any portion of the various military forces to permanent duty as part of local civil-defense reserve forces. This is an example of OCD's acceptance of a stringent limitation without much argument. In our view, it seems mandatory that OCD constantly point out the importance of directing and assisting the civilian population in disaster situations, and of arguing that there are few, if any, military tasks within the capabilities of the National Guard, for instance, that conceivably could be more important in a nuclear attack on the U. S.

This is a most frustrating situation, because civil defense does require an identified, assigned, dependable, trained reserve. It is not wise to depend heavily on the last-minute availability of groups of forces, with several lines of command not practiced in collaboration with each other or with civil-defense organizations. Nor is it wise to be forced to place sole reliance on the massive use of untrained or unassigned volunteers.

An analysis of the possibilities of civil-defense reserve forces was begun in an OCD staff paper entitled "Civil Defense Aspects of a UMT Program -- Summary." The conclusion on manpower needs of that paper* should be explored further in connection with the analysis of manpower capabilities. In this study, OCD subordinated its requirements to those of the military. In our view, it does not seem necessary for OCD to judge the relative priority of civil-defense and military missions, a judgment that must be made at a higher echelon. Rather, we think that OCD should state the manpower requirements of civil defense and actively seek the authority and funds to insure that these requirements are fulfilled.

Current Civil-Defense Organization and Operations.

Civil defense, particularly at the local level, has sometimes been described as "existing government operating under conditions of extraordinary emergency." Perhaps a more realistic definition would be "a state of mind assumed by existing governments for such emergencies." Elements of this state of mind include the planning for effective use of available resources to counter and protect against enemy attack; the performance of communications, direction, and control duties during the immediate attack period; and the taking of such survival and protective actions as

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* Though universal military training (UMT) cannot be justified by civil-defense needs alone, civil defense could effectively use up to some 6.3 million UMT personnel not required for military service, according to this study.

rescue, fire fighting, and debris removal during and immediately following an attack.

The resources available for these operations usually consist of the shelter spaces already located and stocked; the plans for their use and for other civil-defense actions; the existing government personnel and facilities; the existing protection forces, e.g., police, fire departments, public health service, National Guard; a headquarters facility for direction and control; and the knowledge, skill, aptitude, and experience needed to carry out emergency, disaster-type operations. It is the task of the local civil-defense official to provide this knowledge, skill, and experience for civil-defense operations.

Even when local governments recognize, endorse, and support his civil-defense responsibility, a civil-defense official is apt to be handicapped in his efforts to educate and train people in civil-defense operations by the fact that the need for civil defense -- for protection against nuclear attack -- is considered remote and, besides, is unpleasant to contemplate. This is and probably will remain a serious barrier to effective education and training actions, and to creating a capability for dealing effectively with nuclear attack.

Further complications arise from the division of responsibility between the OCD -- for protection against nuclear attack -- and the OEP -- for dealing with other types of disaster. As a result there can be confusion in the local civil-defense organization, which is the operational instrument for both agencies.

The remedy for this situation, i.e., for improving the effectiveness of local civil defense, is, we believe, contained in the following recommendations:

1. In organizing for emergency operations, OCD should expand its emphasis from predominant concern with wartime nuclear attack to a total-spectrum approach in which all types of disaster or emergency situation are considered. This may require changes in OCD's internal policy, in the statutory authority under which OCD operates, in the relationship of OCD and OEP, and in the division of responsibility between those agencies. These changes should be identified and carried out.

2. Study should be undertaken to determine the organizational devices that should be developed and used at national, state, and local levels to achieve better integration of all emergency functions.

EXTENSIONS TO SHELTER PROGRAMS

The current fallout survey-and-slanting program appears to us a contribution to civil protection of permanent significance. However, our purpose is not to dwell on successes but to focus on deficiencies in the OCD research program. These include, in addition to deferment of the duck-and-cover problem, the following limitations:

1. The current program applies to ground bursts but not to air bursts.

2. It applies to cities which are not targeted for attack, or which escape prompt effects, but has not been designed for cities which are exposed to direct attack.

3. It leads to partial, one-sided public education, and to a partial research and engineering competence for the country. It also can lead to a decrease in the general credibility of OCD's statements, particularly among the more highly educated public. Such a one-sided program of public education is a poor foundation for implementation of any set of contingency plans during the pressures of an emergency.

4. There is essentially no federal financial support for protective construction other than for fallout shelter in new federal buildings and for emergency operating centers.

We think that sooner or later, by one route or another, continuation of <u>any</u> civil-defense effort will require implementation of shelter concepts which take account of prompt effects and fire. It is almost equally probable that the constraints, within which such a more general program must live, will force some degree of tailoring of any investment in shelter to the hazards most probable for any given locality, whether fallout, prompt effects, or fire. In other words, it would be a risk-oriented program.

It is not possible to predict future plans and policies in detail, but we can identify elements of any such program which strongly indicate research requirements, and we can specify in some detail the characteristics of desirable research programs for the future. This is attempted in the next few sections.

<u>Elements of a More Effective Shelter Program</u>.

To take account of different local hazards, it is necessary to protect against various levels and combinations of blast, thermal, and

initial radiation intensities and fire and fallout. All these effects must be considered in making decisions regarding a local shelter system.

Fortunately, development of shelter against prompt as well as delayed effects can be accomplished in many ways, each, however, having important limitations. This emphasizes the advantage of a program featuring many quite different elements.* In the following list, which illustrates the variety which is possible, we indicate some of the more important limitations of each approach to providing shelter development:

1. Identification and classification of the prompt effects and fire capabilities of existing structures. The National Fallout Shelter Survey (NFSS) inventory identifies shelter areas without regard for prompt-effects or fire protection requirements or possibilities. It would seem sensible that in target areas where prompt effects or fire represent as great a danger as heavy fallout, shelters that also protect against prompt effects and fire be so identified to local civil-defense officials. This would require a study of NFSS shelters. Generally speaking, identifying a shelter in this way is inexpensive; but it will nearly always be low-intensity shelter, protecting against injuries and casualties only in areas of overpressures of a few psi. Also, areas of low fire risk should be identified.

2. Upgrading existing shelters. Areas subjected to low psi are large, involving a far from trivial fraction of the population. Further, upgrading the blast and fire protection in these areas can involve inexpensive and simple countermeasures. For example, use of special window screens can eliminate both thermal and glass-missile injuries, and reduction of fire vulnerability often requires only simple cleanup-type actions. Cost-effectiveness of these countermeasures depends on whether lives saved or injuries prevented are used as an effectiveness measure, but it is good in any case. Only rarely will inexpensive modification of an existing structure provide protection above the 10-psi level. But injuries would be greatly reduced in NFSS shelters subjected to low-intensity prompt effects if inexpensive modifications, based on careful analysis, were made.

3. Generation of prompt-effects shelter by slanting new construction for dual use. The most feasible and inexpensive program to produce prompt-effects shelters would

* For a noteworthy effort to develop a multi-element program, see "Area-Wide Shelter Systems," OCD-OS-63-149, Stanford Research Institute, December 1965.

be by slanting the design of new construction to provide greatly increased protection capability at slight additional cost. In the simple and standardized configuration used in Sweden, standard 15-psi shelter spaces cost about $50 per person, incremental.* This is about five times more expensive than a fallout shelter space, but only about one-fifth the cost of a single-purpose shelter space.[9] In individual buildings, slanting can produce either good-quality prompt-effects protection at and below about the 10-psi level, or somewhat more expensive, good-quality protection at higher overpressures, depending on the decision whether or not to install blast doors. In addition, in large metropolitan projects of many kinds, design modifications of buildings and of the layout of streets and buildings can provide, at low incremental cost, large amounts of shelter and protection against fire spread where they are needed most: in metropolitan areas.

4. Federal construction of special-purpose shelters. In addition to providing fallout shelter space in new federal buildings, federally supported shelter construction in the United States is usually considered appropriate solely for emergency control centers or for other particularly important purposes. Federal support, however, is the basis of the Norwegian shelter-construction program, and may be the only feasible way to provide shelter in some places in the U. S. The federally supported pilot civil-defense system referred to later would include federal construction of some single-purpose shelters, as well as 100 percent subsidy of some slanted construction.

5. Provision of short-warning protection in and near new and old construction. Short-warning protection refers to sheltered spots that are readily accessible and usable by people for short time-periods. The best example is the foxhole, but similar protection can also be designed into new construction. The shelter provided need not be limited to low psi, but it may not be suitable for extended periods of occupancy. This subject needs more intensive study.

Approach to a Supporting Technology.

Our assumption is that a plan or program designed to increase shelter progressively would use many or all of the elements just

* Corresponding OCD estimates are for about $60/person.[10]

identified, and quite possibly additional elements as well. The mix of elements would presumably be optional in some sense; but we think that some combinations would compare favorably with the fallout-shelter program when measured against Secretary of Defense McNamara's four criteria for civil defense.

In connection with these criteria, we feel that complete reliance on maximum cost-effectiveness (i.e., units of some measure of effectiveness per unit cost) as the measure for civil-defense programs is questionable. The planning of systems to provide wartime protection should not be judged solely on this peacetime criterion.* As for the criterion -- "no interference with military capabilities" -- the Committee is concerned that there may be exceptions in its validity. Perhaps, for example, decontamination tasks should be done by trained military or military reserve personnel rather than by untrained civilians even though the resulting exposure to radiation might interfere with the future military capabilities of the military personnel used.**

In any case, the foregoing set of elements seems to call for supporting procedures with the following characteristics:

1. Consideration of all prompt effects.

2. Allowance for relationships between prompt and delayed hazards.

3. Definitions of shelter which are based on probability of injury rather than death, and which indicate the type of protection expected of the shelter.+

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* It should also be noted that civil-defense shelters, procedures, and other equipment maintain their values better than either offensive or defensive weapon systems. Thus, shelters built 20 years ago are still useful, but during those 20 years, supersonic bombers replaced subsonic ones and have themselves become obsolete, along with the ATLAS missile.

** The other McNamara criteria are "civilian control," and "integration with military defense."

\+ Damage assessment studies mostly use "casualties," which refers to death or incapacitating injuries. The unsettled question here has to do with establishment of biological criteria for "casualty," i.e., whether it refer to incapacitation or something less.

4. Shelter categories for different ranges of prompt-effects intensities and delayed hazards.

5. Establishment of biological hazard/safety criteria by which injury is identified for purposes of design and analysis of structures.

6. Both procedures and back-up theory established on an unclassified basis.

These characteristics are not simple to implement, nor is the consequence of their implementation easily made consistent with existing literature and definitions which are heavily weighted toward fallout hazards. In fact, the difficulty of moving in this direction, after so exclusive a commitment to fallout, is perhaps the clearest evidence of the unnecessary rigidness imposed by short-range policy.

The third characteristic mentioned above calls for judging a shelter's protective capability on the basis of injury rather than death. We realize that shifting to the use of the injury criterion would greatly reduce the apparent effectiveness of a shelter, measured in weapon intensities against which it would protect. Nevertheless, we recommend that OCD adhere to the principle that the term "shelter" means protection against all but minor injuries. Our concern here includes both the requirements for rapid recuperability and for lessening the medical burden.*

Establishment of procedures and the back-up theory on an unclassified basis is made somewhat difficult, though by no means impossible, by the classified status of weapons-design data, which in turn requires security classification of warhead spectra. But if this technology is to be widely applied, be subject to improvement, be taught in nuclear-engineering courses, and be debated in similar fashion to the fallout-shielding technology, it should not have classification barriers.**

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* It has been argued that glass missiles could be ignored as a hazard because injuries from this cause are unlikely to disable or kill at low overpressures, while at high overpressures the problem is academic because death is likely from many other causes.[11] Similar arguments have been made for initial nuclear radiations, and, to some extent, for thermal radiation. This illustrates the deemphasizing of non-incapacitating injuries which comes about when protection criteria are based on disabling injuries or death.

** Classification barriers against public release of weapon-emission spectra need not impose a serious problem in the design of an effective civil-defense system. Unclassified information can be made available for shelter-shielding calculations which would result in quite acceptable levels of overdesign.

The hazard-safety criteria referred to place entirely different biological phenomena on a common basis; this must be done to some extent arbitrarily.

Technical Requirements.

In view of the fact that statements have been made, at least since 1956, that existing technical knowledge would support a blast-shelter program, one may wonder why so much research is important to an increase of the U. S. capability to shelter against prompt effects. The reason is that many of the five program elements have not yet been seriously considered. The U. S. could have built prompt-effects shelters like those in Switzerland, using the knowledge of about 1956; but a survey program to identify and appraise existing prompt-effects protection calls for technological development beyond that of 1956.

The point is made in Part II that the research on cost and effectiveness does not necessarily produce the design and analysis technology; many definitions, features, and requirements are quite different. But the research to support cost and effectiveness studies is essentially the right type of research. It needs complementing, some change of orientation, and above all, conscious direction toward design and analysis objectives to achieve practical applicability.

Despite the extensive gaps in our knowledge, it is our impression that a first-generation prompt-effects-protection analysis technology could be produced in perhaps a year, if it were a focal point of research with clearly stated operational requirements.

Part II discusses several research fields in some detail; here we might mention a few of the gaps where more information is required:

1. Fundamental work is still needed to obtain data on the flux of injurious missiles produced by glass panels of various types exposed to overpressures and dynamic pressures of different characteristics.

2. Similarly, development of curves for analysis of thermal burn or flashover probabilities need further development.

3. Data on collapse probabilities for panels and panel components of various types and mountings, subjected to pressure waves of various characteristics, currently under development, may be applicable; but rules for estimating building-collapse probabilities need development. Even so, the panel data seem far more important. Additional research is needed on panel strength, wall strength, column strength, etc., to get information that will be needed in belowground as well as aboveground

structures, particularly since such data are of concern for the belowground structures needed to protect against moderate to fairly high levels of overpressure.

4. Data on initial-gamma-ray penetration into structures need development and, possibly, recasting to incorporate probability assumptions about exposure burst-point location and orientation relative to the shelter.

5. Data on neutron penetration into compartmented structures are fragmentary, from both computation and experiment, and need systematic extension.

Additional Requirements.

When the concept of shelter is broadened to include prompt effects, there will be a need to develop studies and literature with variety similar to that now existing for the fallout shelters. Typical designs, cost studies, survey manuals, prototypes, and other developments would all, presumably, be required. OCD has, in fact, been carrying out cost studies of a standardized 15-psi shelter, it has developed a design literature which probably would require reorientation, and it has engaged in surveys from a somewhat different point of view.[1] Actually the situation appears to be somewhat similar to that pertaining in about 1958 to the fallout-radiation-shielding program, when the engineering design and analysis procedure did not exist, but a great deal of accumulated experience and conceptual development had taken place.

Problems of technical education would be more severe than has been the case for fallout-shielding design, because of the variety of different physical phenomena which present hazards. The pattern of architect/engineer certification courses could probably be applied successfully; and it is our understanding that some movement to incorporate prompt-effects data has already occurred in those courses.

Pilot Civil-Defense Systems.

A pilot civil-defense system that included both single-purpose and double-purpose shelters, that served a typical cross-section of the population, and that was manned and organized and equipped would be a research and training instrument of unique value.* In the construction stage, data on costs, materials, and construction techniques would be forthcoming; in the organization stage, extremely valuable knowledge of

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* The 1959 prototype construction (see Part III, page 55) was limited to a proof test and cost analysis of design types; it was never part of a complete system.

manpower requirements and availability would be uncovered; as an established system, it would have a continuing value for training purpose and in testing new techniques, as well as providing a vital service in peacetime emergencies.

The cost and feasibility of development of a few local systems which exemplify organizational and operational procedures as well as various shelter options should be investigated. These could provide the research community with feedback necessary to make all elements of the research and development program as healthy as the fallout shielding program.

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P A R T II.

T E C H N I C A L

P R O B L E M

A R E A S

PART II. TECHNICAL PROBLEM AREAS

In this part of the report we discuss research pertinent to shelter programs; we do not cover all the research concerned with civil-defense or disaster problems. For example, no attention is given to electromagnetic pulse (EMP) effects on electronic or electrical equipment, or to the variety of postattack problems, nor are such important civil-defense problems as warning, communications, or shelter habitability covered. We do discuss studies of hypothetical nuclear attacks and the research in the major weapon-effects fields.

Many research projects are concerned with problems that are important to both statistical studies of hypothetical-attack situations and to the design and analysis of protection against weapon effects. However, it is an important fact that the data, concepts, and terminology for the attack studies are not necessarily appropriate to design and analysis: The "diagnostic" studies do not reasonably lead to "therapeutic" results, and in the prompt-effects area the latter are neglected. More work on countermeasures would give better balance to the programs. One further general observation: the account of research on fallout and on fallout-radiation shielding exhibits the advantages of feedback from an active operational program and of working toward well-defined objectives when it is contrasted with the fire and prompt-effects research where there is no comparable feedback and where objectives are incomplete.

STUDIES OF HYPOTHETICAL NUCLEAR ATTACKS

Studies of hypothetical nuclear attacks consist of computer research on the effectiveness of alternative civil-defense postures, for which very general assumptions are made about availability and effectiveness of shelter. These studies have the potential of producing more-refined information through use of parametric studies of subportions of shelter programs which reflect local differences in risk. They might also be used to give insights into manpower requirements.

General Comments on Attack Studies.

For well over 10 years, computers have been utilized to analyze the consequences of nuclear attacks on this country. Now far more sophisticated, these studies require four classes of data and models to represent physical, social, or biological phenomena:

1. Models for initial conditions, including population, resources, attack, and active countermeasures; these models provide data on location, size, type, height of burst, and time of a set of nuclear explosions.

2. Models for hazard intensities, including blast, fallout, fire, and debris; these models provide intensity estimates as a function of position throughout the country or some specified area.

3. Responses, including damage or casualty criteria for persons, for other living populations, and for resources in general; these responses can provide inputs to various damage-estimate studies, on both a local and a national scale.

4. Models for social and economic systems, including power, transportation, industrial, agricultural, and local economic systems; they can provide inputs to many studies of postattack developments and recuperability of those systems. Only limited progress has been made on these complicated system models.

Our main attention is directed to 2 and, to a lesser extent to 3; we have few comments about initial conditions or problems of modeling social and economic systems.

Both classified and unclassified studies of the number of people killed or incapacitated by different types of nuclear attacks exist.* Despite the magnitude of the effort and the quality and growing quantity of the unclassified literature, we believe that the nature and main conclusions of these studies have not reached the engineering and scientific community and the politicians who make and implement public policy. In this connection, the use of these studies to influence major policy decisions makes it extremely important to be completely candid in presenting them, and to have their public documentation as complete as possible.

Some Problems of Inputs and Models.

The following conclusions are selected from many that could be given:

1. Studies of the number killed or incapacitated by a nuclear attack generally have used curves of casualties

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* See Appendix VI.

as a function of weapon size, and of distance or overpressure. Some of the studies simply scale the Hiroshima and Nagasaki data to the kilotonnage of interest. This procedure has serious faults: first, because free-field intensity curves for blast, ionizing, and thermal radiations for comparable burst conditions and varying yields are not parallel, and have quite different slopes; second, the location of people (in the open or in ordinary residence or commercial structures) rather strongly affects the range for a given percentage survival by something like factors of 3 to 5 for persons in the open versus those inside concrete office buildings. In recent models the different casualty-producing hazards are separately treated, and, to some extent, treated from first principles. These make possible a far better understanding of the problem of shielding against prompt effects, even though refinement of these models is needed.

2. An additional assumption commonly made is the "cookie-cutter" assumption that above a fixed psi people not in specifically designed shelters are casualties, while people located where free-field overpressures are below this fixed psi level are not casualties. The overpressure level associated with 50% overall casualties, based on the earlier estimates for Hiroshima and Nagasaki, is about 8 psi and has customarily been used for this cut-off level, although other values have also been used.[1] The "cookie-cutter" assumption is very useful in highly aggregated studies, but it is clear that for studies that attempt to show the sensitivities of specific design details, it can give misleading results. For example, an assumption of "no casualties below 8 psi" would be inappropriate for a study of 5-psi shelters. The procedure must be used with care.

3. Models do not explicitly take account of synergistic effects* because very little is known about important synergisms. In this regard, the newer response models are inferior to the older ones, because synergistic effects certainly contributed to casualties in the Japanese disasters and therefore were implicitly taken into account.

4. Current attack studies are not, as yet, very detailed on the postattack recovery process. Efforts should continue toward developing a step-by-step interaction between elements of that process; they should be designed to determine the sensitivity of their results to varying methods and levels of effectiveness of management of the

* Combinations of effects in which the total effect may be greater than the sum of the component effects.

postattack recovery process. This sequential analysis should extend into the period when ecological considerations are important.

5. A problem area in which we have found little data is the examination of the enemy attack designed specifically to impede, delay, or even prevent national recovery. Such tactics as attacks concentrated on producing both long- and short-term bottlenecks in key national capabilities, or repeated attacks that may be weeks apart and in various forms, should be examined as to their consequences.

6. A related problem for which data are not available is the effectiveness of local civil-defense operations in an attack period. One aspect of this problem is the effect of different types and lengths of warning on shelter occupancy. The length of warning available and the confidence felt in the warning and its length has a major effect on the shelter occupancy when the attack comes. The types of expedient protective action that can be taken, depending on length of warning time, include evacuation, use of short-warning shelters, or actions to decrease vulnerability to thermal effects.

7. A limiting case for nuclear attack, which deserves more study, is the use by the enemy of an imminent threat, for example, the use of an ultimatum against a single city. An analysis of such a situation gives information on the courses of action available to a city's population, their dependence on the time available and the popular reaction to them; it throws some light on the factors that influence the decision-making process; it reveals some likely consequences of various actions, not only in mitigating the effect of an attack, but also in disrupting the community without the follow-up attack.

FALLOUT

As we mentioned earlier, research on fallout phenomena benefits from the fact that it supports an active program of fallout-shelter surveys, shelter planning, etc.

Fallout Physics.

There has been steady progress over the past few years on fallout-physics research; and this varied field now needs a comprehensive review monograph.

We consider this field in four subdivisions: 1) the physics of the explosion, of the formation of radioactive particles, and of the radioactive cloud; 2) transport and distribution of the fallout; 3) emission spectra for the fallout radiations; and 4) biological problems generated by fallout. A firm knowledge of the fallout-particle size and activity distribution depends on an understanding of explosion physics, and is a prerequisite to reliable calculations of the space-time distribution of grounded fallout material.*

Applications of this research include: 1) the spectra on which estimates of fallout shielding depend; 2) fallout models for studies of hypothetical attacks; and 3) initial conditions for postattack studies of decontamination procedures and ecological problems.

The particle size and activity distribution still requires additional study. This is a particularly difficult problem because there are data for such a limited number of surface types. Among others, there is the problem of why small particles are present in fallout-particle mass distributions in greater number than predicted by calculations. This suggests that fragmentation could have occurred during particle transport, or during sieving (in carrying out experiments), or that vertical wind velocities were high enough to inject small particles into the lower atmosphere. Other unresolved questions are mentioned in Appendix VII.

The division of the radioactive debris between small particles** which constitute long-term fallout, and the large particles which constitute the early fallout, has never been established accurately. Current estimates of the fraction of the radioactive debris which comes down as early fallout differ by a factor of nearly 3. It is our impression, however, that current knowledge of the particle activity and size distributions would make possible a more accurate fix on this ratio; and this should certainly be attempted.

Second-generation studies of fallout spectra have now been made in which a much better understanding of fractionation effects+ has been

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* It should be noted that the characteristics of fallout from surface or near-surface explosions vary with small differences in height of burst. The physics of nuclear explosions on or among tall city buildings is extremely complex and there are large uncertainties in estimating the fallout effect of such attacks.

** Small particles are sometimes defined as those less than 50 μ and large particles as those greater than 50 μ.

\+ Fractionation is any change in radionuclide composition occurring after the time of detonation which causes the debris to be non-representative of the detonation products taken as a whole.

incorporated, as well as more complete data on the isotope distribution as a function of time, and more complete data on nuclear transitions.[2] Since these spectra are better supported, both theoretically and experimentally, than the older spectrum on which the fallout-shielding data are based, the Committee has recommended that data for fallout shielding be recalculated using a one-hour unfractionated spectrum.*

Experimental fission-product gamma-ray spectra are in fairly good overall agreement with calculated spectra, although there are many differences of detail.[3] These studies should be repeated in the future when more data on individual isotopes are available.

There should be spectra which show fractionation effects at various fallout arrival times, different burst conditions, etc; similarly, the isotope distribution at long-term intervals should be tabulated for standard use in the postattack studies.

Regarding biological problems, we note that OCD does little work in biomedical programs. In light of the extensive work of the AEC in radiation biology, it seems justifiable to depend on AEC for useful input information, once OCD requirements have been made known to the AEC.

The difference between prediction systems for a specific attack and statistical models for studying hypothetical attacks must be recognized. The former would be operational tools for an emergency. For attack studies, the present state-of-the-art seems adequate, because variations due to different wind patterns can be more important than variations due to inadequacies of the model. But as long as the ratio of early to total fallout is so poorly known, we cannot have confidence in our understanding of these processes.

Fallout Shielding.

In fallout shielding, there exists a fairly standardized technology of design and analysis which is buttressed by about a decade of experimenation on both elementary and complex structures. This literature needs a unified presentation, and a reference book on the subject is

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* Excerpt from minutes of 30-31 August 1966 meeting of the Subcommittee on Fallout: "...the Subcommittee agreed to recommend that, for shielding calculations, ... a) a one-hour unfractionated spectrum should be used. However, calculations of the spectra over the period from 1 hour to 48 hours after explosion should be made; b) there should be energy spectrum runs for radioactive fallout (1) fractionated and (2) unfractionated for the thermonuclear fissioning of U-238; and c) the effect of introducing induced activity from elements in the soil on these spectra should be investigated ..." Work along these lines is in progress.

being written. Additionally, revision of both data and models is appropriate at this time to take full account of the accumulating body of data and computational procedures.

The main deficiency in earlier fallout-shielding technology was in the procedure for calculating the radiations that penetrate through a heavy, exterior wall and then penetrate downward through one floor -- the in-and-down problem. For heavy structures, error factors up to 5 were being introduced; the in-and-down deficiency was not serious for light structures. This error for the in-and-down component should be compared with the factor of about 1.5 which is estimated to be the difference between theory and experiment for elementary structures, for all but the in-and-down case. However, the recent introduction of correction factors into procedures for calculating the in-and-down contribution have reduced that error to below the 1.5 figure.

Better fallout-gamma-ray spectra now exist, as has been mentioned, and it is now possible to do much better in calculations of angular distribution for plane isotropic sources.* In view of this, the basic data should be recalculated.

Current procedures for doing fallout calculations take little or no account of such real-life characteristics as fallout ingress into shelter spaces, the non-uniformity of fallout deposit, retention of fallout on shrubbery, and the effect of precipitation on fallout. The resulting errors cannot be well-estimated, but possibly are non-conservative, i.e., give protection-factor values that are too high.

The Subcommittee on Radiation Shielding has attempted to estimate the total error in estimating protection factors, that is, what factor must be applied to the estimated PF to make it conform to the PF in an actual, real-life, fallout emergency. The Subcommittee concluded that the answer is on the order of 2, and could well be non-conservative.[3] The accuracy for light structures is greater than for heavy structures, but the accuracy requirements for light structures are more stringent.

Regarding problems of slanting design and analysis, the methods employed are not unique for a given problem; and there is room for considerable differences of result depending on the approach used and on the skill and understanding of the analyst. For this reason there need to be better mechanisms for codifying engineering practice, as developed and accepted by the best analysts.

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* Fallout uniformly distributed on smooth, level ground exemplifies this idealized radiation-source type.

PROMPT EFFECTS

Prompt effects have been defined as those occurring in the first two or three minutes. They include gamma and neutron radiation, and the thermal and blast pulses. Civil-defense shelter research concentrates on levels of intensities below about the 100-psi overpressure level.

Initial Radiation.

Initial radiation, i.e., the radiation emitted directly from the weapon during the time of energy release, is a hazard in areas where free-field overpressures exceed a threshold of 7 to 10 psi.* Unlike programs in fallout physics, engineering of initial radiation shielding has not yet been worked out. Five main problems stand out: 1) the problem of radiation spectra; 2) the problem of gamma-ray penetration through compartmented structures; 3) the problem of neutron penetration through compartmented structures with the accompanying gamma rays generated mainly by neutron capture in the structures; 4) the problem of identifying suitable data for design and analysis purposes; and 5) the problems of biological response and dosimetry.

There is reason to believe that the programmatic approach to the initial-radiation problems can be similar to that applied to fallout-radiation-shielding problems. There are additional complexities which make the determination of data and techniques a greater problem, with more necessity for a degree of arbitrariness in standardizing procedures and definitions. Initiative to establish these guidelines is required even in the absence of federal policy requiring use of this type of technology.

The position or type of the nuclear bursts cannot be known for an actual attack, hence data on probable attenuation factors might be appropriate for design and analysis, and could be unclassified. They could incorporate source-location probabilities, including probable direction relative to shelter, and even burst-type probabilities.

Data for damage-assessment studies are based on specified burst types and positions, and are quite different from data for design and analysis. But data for either purpose are rather crude at present, and there exist few studies in which theory and experiment on structure-shielding properties are compared.

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* According to H. L. Brode,[4] free-field exposure to gamma radiation from a small (100 KT) weapon is about 600 R at 7 psi; and to a larger (1 MT) weapon it is about 100 R at 8-10 psi, depending on altitude, and is rising very rapidly with overpressure. Even 100 R is not negligible exposure, particularly when taking synergisms into account.

The first problem -- of source spectra -- is a problem of defining spectra which can support unclassified studies of prompt-effects shields. Incident on the shield will be some mixture of (1) early fission-product gamma rays; (2) air (neutron) capture gamma rays; (3) air (neutron) inelastic scattering gamma rays; (4) prompt-fission neutrons; and (5) prompt-fusion neutrons. Evidence to date indicates that prompt-fission gamma rays can be neglected.[4]

The mixture of these components must reflect details of actual weapon design, which have a security classification; hence, the problem of radiation spectra is that of stating unclassified spectra which are suitable for OCD purposes. The present trend toward using spectra of 1 km or 1 mile from source has the advantage of avoiding classification problems;[5] at such distances spectra are rather independent of source details and change slowly with distance from source.

The second problem -- penetration of gamma rays -- involves both generation of the data and experimental confirmation. Cobalt-60 can probably be used for the latter purpose even though its spectrum does not much resemble that of any weapon. Data should also be generated for standard spectra which have not, as yet, been defined. Data for attack studies exist but should be improved.

The third problem -- the penetration of neutrons into compartmented structures -- is currently under active study. For heavy structures, one cannot rely on the simple assumption that neutrons penetrate rectilinearly through the structure. There exist some data for simple box-type structures and computer programs to analyze complex equipment such as military vehicles.[6,7]

With regard to the fourth problem, data may express (1) an arbitrary, prespecified burst type and position; (2) a standard "worst" source direction relative to the shelter; or (3) a probability distribution of directions. Data of the last type are not available at present, but data utilizing arbitrary specification of source location and type do exist.[7-13]

The fifth problem -- dosimetry -- is the problem of estimating biological damage for mixed fluxes of neutrons and gamma rays. Two questions that must be answered here are, first, what type of dose should be used -- perhaps a multi-collision dose* -- and, second, what is a suitable definition of "casualty" in terms of the type of dose selected? (See footnote, Part I, Page 23).

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* Dose defined for a large rather than small object, in which gamma rays and neutrons undergo many collisions.

Thermal Problems.

We identify those thermal problems which can be properly categorized as "prompt" as those of (1) burns directly inflicted by exposure to thermal radiation from the fireball, (2) burns indirectly inflicted by clothing heated or ignited by thermal radiation, and (3) flashover in a shelter area due to thermal ignition.

Shielding against thermal radiation is a simple problem by comparison with shielding against ionizing radiation, but the problem has not been fully explored. The possibility of short warning times leads to the possibility of thermal hazards for a significant fraction of the populace, because of the long range of dangerous thermal intensities. Further, the NFSS shelters have not been analyzed for thermal-penetration probabilities, and many of these shelters have windows that permit direct ingress of thermal radiation. Finally, the populace in general is not schooled in evasive action against this effect, which is a greater hazard for air bursts than for ground bursts.

Data for calculating probabilities for thermal penetration into NFSS shelter areas should be developed. These data should be applied to determine both flashover and burn probabilities, as part of a general analysis of prompt-effects protection by all shelters to which the populace is advised to go upon receipt of an attack warning.

Blast Intensities.

Blast-intensity problems involve data for both free-field and non-free-field conditions. Non-free-field problems can likewise be categorized as (1) those relating to blast parameters inside structures, particularly areas likely to be occupied by people, and (2) blast loadings resulting from multiple reflections and channeling in dense areas of multi-story structures. The biological-response problems -- direct, indirect, and miscellaneous -- involve damage to different parts of the body as a function of the parameters of the blast wave; particularly significant is the wave shape, along with the accompanying winds as well as all the translational events that may be associated therewith. Other than direct damage from the overpressure per se, there is indirect trauma due to penetrating and nonpenetrating debris and to the consequences of whole-body displacement* caused by blast or ground shock.

All of these blast-related effects are involved in the proper estimation of casualties in any damage-assessment study purporting to

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* In cases of whole-body translation, damage would result more from decelerative impact than from the accelerative events during which velocity is gained.

be both adequate and complete. Also, these problems must all be taken into account or circumvented in some realistic way for shelter design and rating activities.

By comparison with non-free-field intensity problems, the free-field problems are relatively well-understood and manageable.

In the non-free-field research area, both overpressure and dynamic pressures inside structures loom as by far the dominant unknowns. The literature is scanty, exploratory in nature, and characterized by little effort to bring calculations and experiments into agreement. About the only part of this problem which one might consider under control is the fill time and pressure calculations for a cavity with an aperture.

What seems to be needed is a substantially increased and concentrated research effort to develop suitable methods for estimating interior pressure/time histories, including the fast-transient spikes, and panel loadings as functions of structure configuration and type, and incident-wave type.* To accomplish this, an experimental program featuring additional shock-tube research, research with chemical explosives, and instrumentation research is needed. Such a program should include a substantial theoretical program featuring application of known computer methods to two-dimensional configurations. External configuration effects should be a part of such a program; they do not take precedence and are not justifiable as an independent effort.

Structural Response and Debris Problems.

There are at least two types of structural-response problems, and at least four distinguishable classes of debris problems from the point of view of biological damage. Structural-response problems are concerned with failures of internal or external wall panels or of load-bearing beams and columns.

The debris problem types are: 1) the problem of puncturing or lacerating fragments of glass and other frangible materials; 2) the problem of non-penetrating missiles, which may be generated through fragmentation of other types of panels; 3) the problem of high-temperature dust carried into structures by the blast wave; and 4) the problem of dust created by spalling and building collapse.

Casualties may occur as a result of blast or missile hazards which exist when panel failure opens up a shelter area and exposes the people

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* For information on OCD's ongoing research in this area, see pages 14-20 of "OCD Research Progress Report" 1 July 1968 to 31 December 1968, Office of Civil Defense, April 1, 1969.

within, or as a result of building collapse. Hence a physical grasp and engineering capability is required both for detailed damage-assessment studies, and for shelter design and analysis.

Most building types would collapse due to the fact that the load-bearing panels may fail or the roof may not be tied to its supports. Hence the internal and external panel-shatter problems are aspects of the collapse problems of some types of buildings, as well as dominant problems of shelter-area shielding from direct blast effects and missiles.

Investigations have been contracted by OCD to list panel-shatter probabilities, as dependent on some of the main identifying characteristics of common panel constructions.[14] This work should be continued, with both shock-tube experiments and correlated analytical studies. In addition, existing estimates, even if rough, of the interior and exterior blast loadings of buildings should be used to generate procedures for estimating building-component-collapse probabilities.

The lack of data and adequate theory for hazardous glass-missile fluxes is about as glaring a gap in our knowledge of prompt-effects hazards as is our lack of knowledge of blast pressures and winds inside buildings. The distance-mass-velocity spectrum for glass missiles needs to be determined by shock-tube experiments for many panel types and mountings; the theory of missile transport should be made two-dimensional, and various casualty probabilities which result should be identified. Despite the work already done on this problem, it has hardly been more than well-begun.[15] First-generation methods for estimating injury probabilities are far from complete, and what exists needs refinement. Again, a continuing program in which theory and experiment are well-coordinated is called for.

The problem of larger missiles, encompassing a high percentage of hazardous, nonpenetrating debris which result from building damage, is so closely analogous in its various components that it should probably be conceived as part of the same research program. Certainly the mass-velocity-distance-time relationships for larger and heavier debris has much in common with whole-body translation. It is quite clear that the aerodynamics of whole-body translation deserves much more study, particularly for all positions, including supine and prone, and involving problems of disturbed wave forms in the open and from various wind patterns inside structures when near orifices, reflecting surfaces, and in corners close to and far away from high-velocity jets of wind.

The problem of hot dust-laden air in open shelters appears to be of lesser significance, but merits enough further exploration to determine if conditions exist in which it might become important.* The same could be said for building collapse due to ground shock.

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* People were reported killed in Germany during World War II as a result of inhaling dust. Non-line-of-sight second-degree burns were recorded at the Nevada Test Site on several occasions.[15-17]

Biological Problems.

Biological problems require a continuing effort. OCD should keep fully aware of the results of AEC- and DASA-supported programs, in fact, OCD should seek from AEC and DASA the technical data needed in civil defense. Generally speaking, we feel that the OCD research staff should include one or more individuals competent to work towards a better understanding of biological damage due to nuclear weapons effects.

It is helpful to recall here that direct blast effects are those due to the pressure variations associated with the blast wave. Indirect effects include biological damage from (a) penetrating and nonpenetrating debris (missiles), (b) the consequences of whole-body displacement (tumbling and impact), (c) non-line-of-sight thermal injury due to hot, dust-laden air, (d) dust (which may be radioactive) sometimes occurring even inside closed structures, and (e) blast-induced fires.

Direct blast effects on animals are known, though incompletely, for disturbed or atypical wave forms. However, such effects as lung damage and eardrum failure or whole-body-translational effects cannot be considered adequately understood.[1] Likewise the interpretation of experimental data from several animal species is not yet firmly established due to uncertainties in some of the interspecies scaling procedures. Even so, tentative though incomplete biomedical criteria for assessing hazards due to blast-induced pressure variations have been formulated; they have also been formulated for indirect blast effects as well as for thermal and ionizing radiations.

In the area of high velocity, penetrating projectiles there has been much work, and biological damage criteria are at hand. For low-velocity, penetrating and lacerating missiles, as well as nonpenetrating ones, only first-generation investigations of biological effects have been carried out and crude tentative criteria formulated. These criteria have not been used to assign casualty probabilities to missile fluxes. Also corresponding criteria for very low-velocity, lacerating missiles such as would result from low-psi shattering of window panes do not now exist. Continuation and extension of the work currently under way is appropriate at this time.

As mentioned above, tentative biomedical criteria for direct and indirect blast effects, and for ionizing and thermal radiations are at hand. All need refining and considerable research is yet required to finalize any of them for man; in particular, the whole age range from the infant to the very old should be considered. Work has only just begun on establishing tentative criteria for combined injury or effects when the stressing agent represents one of the possible combinations of blast, thermal radiation, and ionizing radiation. A study of the data from Hiroshima and Nagasaki emphasizes the fact that combined injury occurred with high frequency.[1,18] These data also indicate that

the incidence of damage from more than one effect increases as the distance from ground zero decreases. Further, it appears that one result of exposure to ionizing radiation is to decrease the victim's recuperability from other types of injury.

FIRE

Fire and fallout are delayed effects of nuclear weapons, with fire usually occurring first -- developing and continuing for time periods of the order of hours.

Fire Research.

Fire problems are many, complex, and require a substantial, continuing research program with many facets.

Three major categories of problems can be identified: 1) ignition problems in shelter spaces, buildings, or regions; 2) the physics and chemistry of very large fires, with inclusion of fire-spread mechanisms; and 3) problems of the development of countermeasures against fire and thermal hazards.

The study of ignitions requires thermal-penetration data, as already mentioned; these are now becoming available.

After the first few minutes of prompt effects, during which ignitions and thermal injuries occur, there is a period of the order of several hours to several days when fire and early fallout are dominant hazards. Thus there are two periods for which thermal and fire models used in damage assessments are applicable, and when two classes of countermeasures are needed: One is against the thermal pulse and the ignitions associated with it; the other is against the developing fire.

The OCD program has broad coverage, with major emphases on problems of very large fires, and on applications to damage-assessment studies. It does not appear to be feasible to scale some important features of very large fires, particularly fire storms, since some pertinent phenomena may not appear in test burns even as large as Flambeau.*[19] Since realistic data are scarce, every piece of information of significance, e.g., data from Japanese and German disasters in World War II, must be utilized; and contingency plans for the study of future large-scale fire disasters ought to exist.

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* A 1962-66 research program on mass-fire behavior that included test burns of brush and trees piled in "streets." The largest covered 40 acres.

Beyond this, a concentrated effort to understand and model small fires might pay off in a capability to approximate mass-fire effects with greater confidence, and to identify sets of effects which can be studied to some extent separately.

We would like to see increased effort directed to countermeasure work,* though not at the expense of ignition and fire studies. The damage-assessment models should be used to estimate the requirements for achieving maximum savings of life and resources through early-time fire fighting; also to estimate the vulnerability of fire fighters during attack. Fire models are an essential ingredient of studies of postattack conditions.

There are a number of problems for which a solution would have no immediate payoff, but which, if not understood, throw into serious question the results of much of the other research, including all the casualty studies of nuclear attacks. Included among these problems is the physics of atmospheric transmission of light, which has not yet been adequately engineered for use in studies which require this information. In addition, the chemistry, physics, and engineering of combustion of common materials are not well-developed, as evidenced by the variety and futility of attempts to standardize combustibility ratings.[30] It is appropriate for OCD to make a substantial contribution to support of a broad program of basic as well as applied research on these problems.

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* We believe this recommendation should not be applied to work on smoke screens, which seem to us to have reached a point of development where significant further improvement is unlikely. Without a clear-cut operational requirement for the improvement of smoke screens, the funds for refining them would be better spent on reducing vulnerability to fire, and for preventing fire growth and spread.

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PART III.

GENERAL

ASPECTS

OF

CIVIL DEFENSE

PART III. GENERAL ASPECTS OF CIVIL DEFENSE

A RECENT HISTORY OF CIVIL DEFENSE IN THE USA

We begin this history of civil defense in the U. S. at the occasion when Public Law No. 81-920 was signed into law January 12, 1951, creating the Federal Civil Defense Administration. With amendments and in combination with Executive Order 10952, this remains the legal basis for civil defense in the U. S.[1] Section 2 of the law gives a declaration of policy:

> ... It is the policy and intent of Congress to provide a system of civil defense for the protection of life and property of the United States from attack. It is further declared to be the policy and intent of the Congress that the responsibility for civil defense shall be vested jointly in the Federal Government and the several States and their political subdivisions. The Federal Government shall provide necessary direction, coordination, and guidance; shall be responsible for the operation of the Federal Civil Defense Administration as set forth in this Act; and shall provide necessary assistance as herein authorized.

Section 3 of the law gives definitions, including the following excerpt:

> The term 'civil defense' means all these activities and measures designed or undertaken (1) to minimize the effects upon the civilian population caused or which would be caused by an attack upon the United States, (2) to deal with the immediate emergency conditions which would be created by such attack, and (3) to effectuate emergency repairs to, or the emergency restoration of, vital utilities and facilities destroyed or damaged by such an attack.

Passage of the federal law occurred five and one-half years after the attacks on Hiroshima and Nagasaki, and it was primarily, but not exclusively, oriented toward attack with nuclear weapons. Nuclear attack is still the main focus of civil-defense activities.

Program Orientation, 1951-1956.

Direction of the Federal Civil Defense Administration (FCDA), an independent agency in the federal establishment, was first the

responsibility of Millard Caldwell. In his first appearance before the House Appropriations Committee, after being in office for about two months, FDCA Administrator Caldwell made it clear that a blast-shelter construction program was infeasible at that time. He apparently estimated that blast shelters would cost about $1,500 per space, that they would take too long to build, and that warning times might not permit their full utilization. Instead, he proposed to modify existing structures, although he did not anticipate that this would result in a significant cost reduction.

A few months later the proposal had been further scaled down to a program for identification of existing buildings which would provide suitable (blast) shelter, and for modification of structures which could be made into shelters. The cost for providing shelter in this manner was apparently estimated to average about $25 per shelter space, half to be financed by the federal government.[2]

As it took shape in 1951, the FCDA proposal to Congress was for $6.5 million to survey a number of cities, and a total of $865 million dollars, spread over three years, to match funds with the states for modification of existing buildings, to build some group shelters to meet serious deficiencies, and to provide equipment and services. But Congress felt that further study was necessary before proceeding, and struck out all funds for the shelter program, both in 1951 and 1952.

Consistent with its effort to make maximum use of existing facilities and to get a program underway quickly, FCDA prepared a large number of technical manuals, bulletins, and public and administrative guides.[3] In the absence of funds for shelter, guidance to the public emphasized the duck-and-cover approach to protection, and featured a concern for public understanding of the effects of nuclear explosions. Much use was made of the first edition of <u>Effects of Atomic Weapons</u> in preparing these documents.

The early FCDA program was reviewed by Project East River,[4] in July 1952. The report criticized cost estimates as being too high, the shelter survey was strongly supported, and major recommendations were made for serious study of the cost and feasibility of a comprehensive blast-shelter program and of various vulnerability-reduction possibilities featuring dispersal of industry and population.

Millard Caldwell was replaced in 1952 by his deputy, James J. Wadsworth, who, in turn, was replaced in February 1953, by Governor Frederick (Val) Peterson. Governor Peterson took advantage of an early appearance before the House Appropriations Committee to compliment it on having earlier voted against federal funds for a shelter construction program on the basis of inadequate research. But after being in office for three years, he indicated to the House Committee on Government Operations his conclusion that Mr. Caldwell's recommendation should have been followed.[2]

Feeling that support was lacking for a government-financed shelter program of a size adequate to provide protection against the new weapons being tested, FCDA Administrator Peterson turned to a policy of evacuation of metropolitan areas, which he admitted at the time was based on two-to-four hour warning time, and would become infeasible with the advent of ICBM's. The earlier emphasis on existing shelter was shifted to an attempt to promote the concept of pay-for-it-yourself family blast shelters. However, this effort met with little success.

The first U. S. thermonuclear device was exploded October 31, 1952; the second on March 1, 1954. The first Russian explosion of this type occurred on August 12, 1953. As word of these enormous explosions became known to the general public, there was new concern about civil-defense possibilities.

This new concern was reflected in the 1956 hearings before the Military Operations Subcommittee of the Committee on Government Operations, chaired by Representative Chet Holifield. The Subcommittee strongly criticized FCDA Administrator Peterson for turning away from the original concept of a shelter program, and stated its opinion that the emphasis on evacuation was a waste of money and effort.

Some Early Research Projects.

From its beginning, FCDA undertook a research and development program. Typically, there was work on shelter designs, on warning, and on instrumentation. A large research contract was awarded by FCDA to Stanford Research Institute for the purpose of devising a system for making national-damage-assessment studies. These studies were conceived of as part of a capability for quick location and evaluation of nuclear bursts. Other contracts followed to develop necessary instrumentation.

In 1956, Project Civil was established at the Berkeley campus of the University of California. This project was for "undertaking the initial study and research necessary to furnish the basis for design and development of the organizational system necessary to execute a national radiological defense plan." The scope of this project was initially so broad that the Military Operations Subcommittee called it "unmanageable" in their 1956 report. In subsequent years FCDA scaled it down and focused it more on techniques for survey of metropolitan areas to identify structures which could provide fallout shelter.[5]

Early in 1956 a much smaller project was established at the National Bureau of Standards to produce radiation data which could be used to analyze structures to determine their radiation-shielding properties. About the same time many other contracts were initiated on a variety of topics featuring radiation monitoring and shelter equipment.

The projects on fallout protection signified a major shift of attention by the FCDA away from the prompt effects of nuclear weapons and toward the delayed effects. Nevertheless, in the years prior to 1958,

progress was made in the design of structures to protect against blast. As early as 1951, designs of blast-resistant structures were produced on contract by Lehigh University; and these designs were tested in the Buster-Jangle series of nuclear tests. In 1952, a manual for design of blast-resistant structures was issued by FCDA.[3] FCDA further participated in Operation Upshot-Knothole (1953), Operation Teapot (1955), and Operation Plumbbob (1957). These test series covered a very wide variety of structure types.

During the 1956-58 period, a manual on blast-protective-construction design was prepared. It incorporated the available concepts and data from Department of Defense research, from the nuclear test programs, and from universities. In 1961, it was published as Manual Number 42 of the American Society of Civil Engineers,[6] and it remains a major contribution to shelter design, along with the "Method A" pamphlet[7] prepared in 1956 by Dr. Nathan Newmark, University of Illinois, who also served with the group that prepared Manual Number 42.

Federal Policy, 1958.

The crystallization of federal policy into a "fallout-only" approach, which would dominate civil defense in this country up to the present,* occurred in 1958.[5] Congressional hearings were held in late April and early May of that year. This was also the year of discussion of the Top Secret Gaither Report,[8] the Rockefeller Brothers Report,[9] and the RAND Report,[10] as well as of the merging of FCDA and the Office of Defense Mobilization (ODM) into the single agency: Office of Civil and Defense Mobilization (OCDM).

The testimony in the 1958 Holifield Subcommittee hearings contains a good bit of evidence that the Subcommittee members had hoped that the Administration would propose a shelter plan which would add protection against fallout radiation to the blast protection and evacuation already incorporated into the 1956 FCDA proposals. The research conducted between 1956 and 1958 had been in that general direction, and the testimony of all the technical witnesses was in agreement that the technical base was adequate for construction of such a shelter system. However, there was also agreement among the technical witnesses that estimates concerning the costs of shelters constructed at that time would be conservative in the sense that costs could be decreased as a result of additional research.

While the hearings were in progress, Governor Hoegh, who had become Civil Defense Administrator in 1957, appeared as a witness before the Committee, and stated that he was prepared to announce a civil-defense

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* Executive Order No. 11490, published in Federal Register, Oct. 30, 1969, discusses shelter against all nuclear weapon hazards. However, it states that shelter design, construction, etc., shall be "In conformity with national shelter policy ...", which still is fallout-only protection.

policy for the Eisenhower administration: "The Administration's national civil-defense policy, which now includes planning for the movement of people from target areas if time permits, will now also include the use of shelters to provide protection from radiological fallout."[5]

To implement this policy the following program elements were given: 1) public education, 2) survey of existing structures on a sampling basis only, 3) research on what is today referred to as "slanting"* designs for dual-purpose use, 4) construction of prototype shelters, and 5) incorporation of shelter into the design of new federal buildings.

Governor Hoegh announced categorically that "there will be no massive federally financed shelter construction program," and that "our chief deterrent to war will continue to be our active military capability. Our active military defense may eventually have the capability of effectively preventing an enemy from striking intended targets. Highest priority is to be given to the development of this capability."

Finally, Governor Hoegh stated that "common prudence requires that the federal government take steps to assist each American to prepare himself, as he would through insurance against any disaster, to meet a possible -- though unwanted -- eventuality. The national shelter policy is founded on this policy."

In summary, the federal policy was to be federal encouragement (non-monetary) and example to the public to build personally financed fallout shelters. As before, there was to be federal investment in deterrence and a prospect for <u>active</u> defense measures.

Congressman Holifield referred to this as "an inadequate step" that "will not do the job."[5] It followed the top secret classification of the Gaither Report and came at about the time of the reiteration of dependence on massive retaliation for deterrence; and it apparently was one of a series of policy decisions made at the highest levels of the Administration.

An immediate consequence of the new policy was the reduction of FCDA research programs for blast shelter, although research into components usable in both blast shelters and fallout shelters continued. In 1958, there occurred the last nuclear test that provided useful information for blast-shelter research.

It should be realized that at the time (May 7, 1958) that the federal policy on fallout protection was announced, a fallout shelter had to incorporate "a shielding mass of three feet of earth, or equivalent

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* Changes in design that will increase protection capability at slight, possibly negligible, additional expense.

mass of other materials, between the occupants and the contaminated area outside, with the further provision that the entranceway be so designed that there will not be a wind-blown accumulation of radioactive dust concentrated around the entrance. Such a design should provide about a 1/5000 attenuation of the free-field radiation intensity outside,* based upon an assumed 0.7 Mev ... fission product fallout."[11,12] This standard was recommended in 1955 by AEC.

This degree of radiation protection had also been implicit in the blast-shelter designs; and it is a factor in all the shelter-program discussion of the time. Shortly after the policy was announced, guidelines were prepared for the Bureau of the Budget to permit estimates of this incremental cost of governmental buildings adhering to the federal policy.[13] Such criteria, together with the rudimentary state of the analysis technology, produced cost estimates that were high enough to suppress this governmental example-setting almost entirely.** Likewise, slanting research in 1958 was extremely rudimentary. And the program for designing prototype shelters which was eventually funded was an expensive program, which produced scant new shelter-design information, especially in comparison with other research expenditures.

Development of a Fallout Shielding Technology, 1956-1961.

The data representing output of the National Bureau of Standards (NBS) project required new computational procedures, because they included angular distributions of exposure for fallout source spectra as well as penetration data for vertical walls exposed to fallout fields. These data became available in mid-1958, though they were not published until after 1962.[14]

Also, during the month of May 1958, the first comprehensive experiments in this country to measure the shielding properties of existing buildings were carried out at the Nevada Test Facility.

Thus, the fall of 1958 witnessed very rapid progress in the development of a fallout-shielding technology. Most of the concepts for the

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* Shielding against fallout gamma radiation is currently described by the term "protection factor (PF)." For practical purposes, PF is the ratio of exposure in a standard unprotected position to exposure in protected places. In these terms, fallout shelter was required to have PF $\geq$ 5000.

** In Fiscal years 1962, 1963 and 1964, Section 301 in the Independent Offices and HUD appropriation acts prohibited use of any money for fallout shelters in buildings of agencies covered by the act. In FY 1965 Section 301 was dropped. Funds for fallout shelters in 16 GSA buildings were approved.

simplest structure types were understood by September, and by December the first drafts of a methodology for surveys existed. The requirements for analysis of surveys led to a classification system which included many categories below the standard for federally financed fallout shelters. By mid-1959, standards for a fallout shelter were for $PF > 1000$,[15] but the rating system on existing structures covered ranges from $PF = 1.5$ up.

By 1960, a manual on the fallout-shielding methodology was essentially completed; it constituted an analog to the manual on blast-resistant design. Draft and preliminary copies were circulated for several years after 1960 before an official version[16] became available. The minimum PF for fallout shelter was reduced to 100 at this time as a result of an OCDM review of fallout radiation intensities likely to follow a ground-burst nuclear attack.

The years 1959-61 also constituted a period of rapid development in the design of experiments to measure shielding properties of structures. An important development was that of the source circulating in a plastic tube with which measurements were made on large buildings; other experiments utilized steel scale models. The experiments used Cobalt-60 radiation which has both penetration and scattering properties sufficiently like the fallout radiation to make a satisfactory simulant.

One cannot say that the detailed procedures and data for the fallout-shielding methodology were completely checked out by 1961, but certainly a general realization of the capabilities and weaknesses existed by that time among the investigators; and these were roughly consistent with engineering practice in other disciplines.

Events and Kennedy Statements, 1961.

The years 1961 and 1962 witnessed a series of international crises, and a focus of attention on civil defense by the Kennedy Administration. In April 1961, the Bay of Pigs invasion took place. On May 25, President Kennedy included the incorporation of civil defense into the DOD in a speech on "an urgent national need."[17] Beginning June 4, the Soviet government precipitated the Berlin crisis by demanding a German peace treaty. This crisis lasted through most of the summer and ended with the erection of the Berlin wall. On July 20, Executive Order 10952 was issued to effect transfer to DOD of many civil-defense functions. And on September 1, it was announced that the Soviet Union had resumed the testing of nuclear weapons. Finally, a year later (October 22-29, 1962) came the Cuban missile crisis.

In his May 25 address,[18] President Kennedy indicated much of the policy which would be pursued by his Administration. He made it clear that, in his opinion, civil defense had little value as an attack deterrent; that deterrence was a property of strong retaliatory forces. Then he stated:

> But this deterrent concept assumes rational calculations by rational men. And the history of this planet is sufficient to remind us of the possibilities of an irrational attack, a miscalculation, an accidental war which cannot be either forseen or deterred. The nature of modern war heightens these possibilities. It is on this basis that civil defense can be readily justified -- an insurance for the civilian population in the event of such a miscalculation. It is insurance we trust will never be needed -- but insurance which we could never forgive ourselves for foregoing in the event of catastrophe. Therefore, under the authority vested in me by Reorganization Plan No. 1 of 1958, I am assigning responsibility for this program to the top civilian authority already responsible for this continental defense, the Secretary of Defense ... The Office of Civil and Defense Mobilization will be reconstituted as a small staff agency to assist me in coordination of these [civil-defense preparedness] functions. To more accurately describe its role, its title should be changed to the 'Office of Emergency Planning.' As soon as those newly charged with these responsibilities have prepared new authorization and appropriation requests, such requests will be transmitted to the Congress for a much strengthened Federal-State civil defense program. Such a program will provide Federal funds for identifying fallout shelter capacity in existing structures, and it will include, where appropriate, incorporation of shelter in Federal buildings, new requirements for shelter in buildings constructed with Federal financial assistance, and matching grants and other incentives for constructing shelter in State and local government and private buildings.

In his July 25 address,[18] President Kennedy reiterated his concern for federal responsibility, as follows:

> We have another sober responsibility. To recognize the possibilities of nuclear war in the missile age, without our citizens knowing what they should do or where they should go if bombs begin to fall, would be a failure of responsibility ... In the event of an attack, the lives of those familites which are not hit in a nuclear blast and fire can still be saved if they can be warned to take shelter and if that shelter is available. We owe that kind of insurance to our families, and to our country. In contrast to our friends in Europe, the need for this type of protection is new to our shores. But the time to start is now. In the coming months, I hope to let every citizen know what steps he can take without delay to protect his family in case of attack. I know you would not want to do less.

The Berlin crisis followed three years of publicity given to the do-it-yourself policy on building home fallout shelters. Not surprisingly, there resulted a shelter boom, with thousands of new entrepreneurs in shelters. Most of their shelters were outdoor, underground designs, and were expensive. Neither the new Office of Civil Defense (OCD), nor the OEP, nor the Federal Trade Commission (FTC)* were in any position to channel or control these public activities, which ran their course leaving the public with uneasy feelings about family fallout shelters.

Congressional Hearings on Reassignment of Responsibilities, 1961-1962.

To understand the division of responsibilities outlined in Executive Order 10952, one should consider three time periods -- preattack, transattack, and postattack. Preattack is essentially for planning and preparation, transattack involved remedial actions, and postattack involves both local and national recuperation, with consequent economic, social, legal, financial, and technical ramifications.

The Secretary of Defense was assigned authority for preattack planning and preparation particularly for shelter programs and emergency communications; he was also authorized to provide financial assistance to state civil-defense programs. Postattack authority was to emphasize emergency assistance to state and local governments, and national damage assessment.

The Director of OEP was given authority to advise and assist the President in determining policy, and reviewing and coordinating civil-defense activities by all federal agencies. In other words, OEP advises the President on planning and preparation assignments everywhere in the federal government both preattack and postattack.

Except for monitoring and reporting authority, no assignment of authority was made in this Executive Order, or has been made since, for the transattack period, except that both the Director of OEP and the Secretary of Defense would presumably advise the President on delegation of authority at that time.

The Holifield Subcommittee hearings of August 1-9, 1961, had the objective of understanding the nature and prospects of this reorganization, and the program to be implemented. The dialogue of the hearings makes it clear that Holifield, and probably a majority of the Subcommittee, applauded the reorganization, but felt that the shelter program was one-sided, in that no provision was made for people likely to

* Both FTC and DOD initiated standards-development work for fallout shelter, but the boom lasted only about five months, and was over before this work was applicable.[19]

be exposed to prompt effects and fire. In fact, the first questions asked Secretary McNamara had to do with the wisdom of encouraging a reverse evacuation into the cities where most of the fallout shelters were located, but where initial effects could be anticipated.

Secretary McNamara was asked whether he had been delegated authority to conduct civil-defense operations in an emergency, and he replied as follows: "Well, I have the duty of planning for the circumstance, anticipating the contingencies that we may face, developing alternatives for continuing operations under those contingencies, but I have no authority to place those plans into effect; only the President has that authority."[20]

Secretary McNamara was also asked in what regard, other than the question of getting funds, the program differed from past programs; and he replied that a federal effort to identify, mark, and equip shelters on a nation-wide basis constituted the main new element.[20]

In general, Secretary McNamara made it clear from the first that the four principles which any civil-defense program would have to satisfy to gain his support were: 1) civilian control, 2) integration with military defense, 3) no interference with military capabilities, and 4) maximum cost-effectiveness.

The Fallout-Shelter Survey, 1961-1962.

Immediately upon assignment of civil-defense responsibilities to DOD and initial staffing of the new OCD, the effort to conduct a national fallout-shelter survey was initiated. In general, the two main problems were: 1) data gathering, literally on hundreds of thousands of buildings, and 2) data analysis, preferably by computer.

The data-gathering problem was rendered much more difficult by the fact that no more than a few dozen people were familiar with the analysis technology. So a large three-stage crash program of education was initiated that was accomplished in a few months. According to information furnished the Holifield Subcommittee by Mr. Adam Yarmolinsky, special assistant to the Secretary of Defense:

> In round numbers, the personnel from the Corps of Engineers and the Bureau of Yards and Docks to be associated with the civil defense training program on a full-time basis is approximately 100. These persons would be responsible for providing training for approximately 1000 supervisory personnel of architect and engineer firms. They, in turn, would be responsible for providing the requisite training for the shelter-survey field engineers, who would probably number approximately 10,000.[20]

The data-handling problem was streamlined by use of Bureau of the Census methods and forms, and by computer-processing at the National Bureau of Standards.

The main part of the program to identify PF 100 shelters, existing at that time, was completed within a year, at the cost of about $55 million.

Throughout the most active period of the survey, a shelter was defined as a structure offering a PF of 100 or greater. Later, this criterion was lowered to a PF of 40 on the basis of studies which showed that of those who would survive the prompt effects, PF 100 shelter would only save relatively few more from fallout radiation than would PF 40 shelter.[31] There are, of course, many more PF 40 structures available to provide shelter.

Following identification, shelters were marked by the familiar yellow signs, and a stocking program was initiated. There has been an active OCD program on identification, marking, and stocking since that time.

The Full Fallout-Shelter Program, 1963.

In 1963, under the leadership of Mr. Steuart Pittman, Assistant Secretary of Defense for Civil Defense, a bill was introduced into Congress to provide both a legal basis and funding for a "full fallout-shelter program."[32] This bill included provisions for: 1) fallout shelter in new federal construction, 2) financial support of fallout shelters in new construction by non-profit institutions, 3) direct technical assistance by OCD to localities in creation of new shelter space, and 4) inclusion of activities in natural disasters among federal civil-defense responsibilities. Funds provided by the bill to support the program came to about $200 million for the first year, i.e., about twice the OCD budget at the time.

The House Committee on Armed Services reported favorably on this bill, after extensive hearings had been held by a Subcommittee chaired by Representative F. Edward Hebert.[33] The bill was enacted by the House of Representatives, but a companion bill was tabled by the Senate.

The Congressional hearings make it plain that there was sentiment in the Subcommittee for a program including protection against prompt effects; in this regard the attitude of the Hebert Subcommittee resembles the attitude consistently expressed by the Holifield Subcommittee in earlier years.

Secretary McNamara stated in these hearings that a fallout-shelter system had priority over an anti-ballistic missile (ABM) system (which was not being recommended at the time), because the latter required the former. Testimony by military men was to the effect that the civil-

defense program proposed "could be regarded as part of a balanced posture." [23]

Just after these Congressional hearings, a study project on civil defense (Project Harbor) sponsored by OCD, was conducted by the National Academy of Sciences under the leadership of Dr. Eugene Wigner. Participants were organized into panels on acceptance and impact of civil defense, education, nuclear attack strategy, future weapons and weapon effects, immediate survival, and postattack recovery. Participants were aware of OCD's existing and proposed civil-defense programs, but their interest was focused on an expanded program including protective construction against prompt effects, an amplified operational system, and problems of postattack recovery:[24] the desirability of the program recommended to Congress by OCD was not specifically considered; it was taken for granted.

(In 1967, Dr. Wigner directed a much smaller study, Little Harbor,[25] which reviewed and confirmed most of the conclusions of the Harbor Report.)

Recent Congressional Testimony.

The years since 1963 have seen advances in the technical foundation for civil defense, together with a degradation of the position of civil defense within the federal establishment.* Before discussing the former, we illustrate the latter.

When Assistant Secretary of Defense Pittman resigned his position in 1964, it had become clear that Congress was unlikely, under the circumstances, to pass the full fallout-shelter program. Following his resignation, reorganization within DOD placed the OCD in the Department of the Army, and made its director subordinate to the Secretary of the Army. This greatly reduced the status of civil defense within the Department of Defense, and was said to have reflected a decision that civil defense had achieved a stable, operational status no longer in need of continuing development.

Congressional testimony clearly demonstrated a disinclination within DOD to follow up the earlier program proposals. In 1966, Secretary McNamara's presentation contained the following statements:

> Considering the great uncertainties regarding the other elements of the damage-limiting program, I

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* Since fiscal year 1962, funds appropriated have decreased annually and for FY 1969 were about at the FY 1960 level, the last year prior to putting civil defense in the DOD.[26]

do not believe that we should undertake, at this time any major change in our present civil-defense effort. We also deleted from our civil-defense request a proposal for initiation of a full-scale shelter-construction, subsidy program, at a saving of $58.6 million. Rather, we are requesting only $10 million for an experimental effort in this area which will give us and the Congress a better basis for developing our shelter program in the future.[27]

Almost the whole discussion in 1966 before the Subcommittee of the House Committee on Appropriations was really a discussion of a damage-limiting posture, of which the main component was an ABM system. Chairman Russell asked Secretary McNamara if a fallout-shelter program would be ineffective without an ABM system. Secretary McNamara replied as follows:

> I think the reverse is definitely true, Mr. Chairman -- that without the fallout-shelter program, it would be unwise to proceed with the ABM. I think both General Wheeler and I feel strongly that that is the case. The reverse, however, would not necessarily be the case. If you decided against an ABM system, a full fallout-shelter program would still be worthwhile. We are not recommending it to you now, but it would still be worthwhile.[27]

Questioned on why, under these circumstances the full fallout-shelter program had been eliminated, Secretary McNamara replied:

> We have made strenuous efforts in the past to obtain larger appropriations and have been unsuccessful. I think it is wise, instead of wasting our time continuing to press for something we cannot accomplish, to spend our resources on other more fruitful areas of activity.[27]

Asked if there were more that could be done if funds were voted for a scaled-down program, Secretary McNamara said:

> The answer to your question is yes, I think we could efficiently use funds in excess of those requested. I will be quite frank with you, I do not think Congress is going to appropriate the funds we have requested, 25 percent above what they appropriated last year. They have cut my request every year for four years, and I think they will do so this year ... We may not have been effective in our explanations, but I do not think we are going to be more effective this year.[27]

Two very remarkable aspects of the testimony in 1966 were Secretary McNamara's testimony on civil defense in Russia, and some comments by Air Force Secretary Harold Brown. Secretary McNamara was questioned about what the Soviet Union was doing about civil defense, and he replied: "Very, very little."[27] In a later exchange, it appeared that he based this comment on the fact that the USSR has not formally undertaken a fallout-shelter program. But in view of the evidence of USSR activity in civil defense* that has been available for over a decade, the comments are puzzling.

Arguing against an ABM deployment, Secretary Brown said:

> The probability of this (a nuclear attack) is rather low, and the value of reducing U. S. casualties from 120 million to 60 million is in the minds of many people, including myself, somewhat questionable. So, the argument is not that we cannot afford it, but that having spent the money, we may not be able to change our policies in any particular way. It may not add to deterrence. It may not make it easier for us to exercise our power anywhere else in the world. Sixty million casualties, or 50 million or 40 million, or whatever, would still be the number of U. S. casualties and would make all-out thermonuclear war on our part very costly.[27]

This exchange illustrated that in DOD, civil defense is evaluated in terms of strategic and psychological implications, a quite different point of view from the original intent of Congress.**

The 1967 DOD testimony before Congress on civil defense went over many of the same points, with very little change, except that the budget proposal for civil defense was further reduced, and there was still more focus on ABMs in comparison to civil defense. Statements that a full fallout-shelter program would be a necessary adjunct to an ABM deployment were made, as were statements that the shelter program would save lives in any case.[28] But these statements were of a perfunctory nature.

The HFPS and the CSP.

Lacking funds to support efforts that go beyond further identification of fallout shelter and encouragement of their development on a do-it-yourself basis, OCD has developed several programs for this purpose in the

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* See Appendix I.

** See Part III, page 51.

past few years. One, the Home Fallout Protection Survey (HFPS), makes use of a table-look-up procedure for estimating basement PFs in homes on the basis of an extremely short and elementary questionnaire. Accuracy of the procedure is quite acceptable. At the end of 1968 some 28 states, including the District of Columbia, had completed their surveys.

The HFPS has been implemented by mail and enumerator, with the assistance of the Bureau of the Census, and the public response has been gratifying. In some states, about 80 percent of the questionnaires were returned, a response far above the normal expectation by Bureau of Census officials.

The Community Shelter Program (CSP) is for implementation by local civil-defense units. It assists development of procedures for informing citizens of nearby shelters, or of the desirability of using basements as substandard shelters, where shelters are lacking. It identifies shelter-poor areas and suggests methods for stimulating shelter development by private initiative and use of slanting procedures in new construction.

Education.

OCD's Staff College was established in 1951. In the 18 years that it has operated, almost 60,000 people have taken its civil-defense courses. These are given tuition-free, and are mostly five-day. The civil-defense management course might be considered the basic one offered. Others are the two-week executive development course for local civil-defense directors, and courses on radiological defense, radiological monitoring, etc. These are typical of the civil-defense training made available to the private citizen or to industry by the federal government.[29] Other civil-defense educational opportunities are available to the public.[30]

For the architect and engineer there are courses in fallout-shielding analysis that are sponsored in OCD. Part of this program is the training of university faculties for giving these courses. Graduates are certified as analysts -- i.e., capable of analyzing an existing structure to determine its capability for protecting against fallout radiation or designing a new one with a given fallout protection capability. By May 1969, a total of almost 18,000 architects and engineers have received certification following examination at the end of these courses. Also OCD funds are used by some universities to offer fellowships in radiation shielding to graduate students in engineering and architecture.

ASPECTS OF THE TOTAL SYSTEM

An understanding of civil defense as a total system requires an understanding of the environment in which it must operate, and of the factors that affect the relationships of civil defense with the other elements of the environment. We discuss some of these factors.

Long-Range Planning.

Parts of the discussion in this report are predicated on the assumption that it is possible and desirable to establish long-range objectives and goals which can go beyond the program being implemented in the country at any given time. Certainly, research and development would be much better oriented in such an environment. That part of research assisting the formation of policy would find its application in this effort; and that part supporting development of systems would receive better guidance.

The initiative for establishing long-range objectives in the Department of Defense can be taken at several levels. These objectives, however, are seldom established, nor do they become the basis for long-range plans or influence budget proposals unless they receive support and endorsement from the Secretary of Defense, or the Joint Chiefs of Staff, or a military department secretary. Obviously, the higher the level of initiation in the Department of Defense, the fewer the superior levels at which it must be reviewed.

Regarding initiative for starting the process of establishing long-range civil-defense objectives, the following may be said. In 1961, when OCD was formed within the DOD, the Director of OCD was an Assistant Secretary of Defense; since 1964 he has been an official in the Office of the Secretary of the Army. Thus, before 1961, while civil defense was an Executive Office responsibility, proposals initiated in the civil-defense agency for the establishment of objectives and of the programs to meet them were reviewed only by the Executive Office, which includes the Bureau of the Budget; in the 1961-1964 period, such review, approval, disapproval, or delay was also exercised by the Secretary of Defense and his advisors; since 1964, the Secretary of the Army and his office has been added to the list of those whose approval is necessary, and who also share the responsibility for initiation. Thus, the demotion of OCD within the DOD structure has, on the one hand, spread the initiation responsibility even thinner and made it less clear-cut, and, on the other hand, has interposed more obstacles to approval of long-range objectives initiated by OCD.

Following 1963, Secretary McNamara in his budget testimony had little to say about civil-defense objectives and programs,[27,28] and OCD has become progressively more insular within the DOD structure. In part this can be attributed to uncertainty regarding developments of ABM systems.

To the extent the relationships between civil defense and ABM systems are understood, ABM decisions appear to have remarkably little effect on the nature of civil-defense objectives and requirements.

Civil defense needs a statement of plans and objectives of longer range than the program being implemented at any given time. Without it, operational requirements for any component of civil defense are likely to be debatable and perhaps nebulous. Independently of the existence of stated operational plans, the attempt to anticipate applications beyond current fallout-only protection, e.g., for an initial-effects technology, and to state their requirements, would, in our view, provide valuable guidance to a large part of the research program of OCD.

What are "Large" and "Small" Civil-Defense Systems?

A review of the pro and con arguments about civil defense in recent literature serves to spotlight topics where disagreement is apparently great.[31,32] Judging from this literature, semantic difficulties and failures to identify basic assumptions have generated misunderstandings which have obscured areas in which there is general agreement.

Outstanding examples of undefined terms which play a large part in these arguments are "large" or "small" civil defense, "serious" or "effective" civil defense, and the like. From the context within which such terms appear, it seems that "large," "serious," and "effective" are often intended to describe civil-defense systems which are sufficiently impressive to affect "deterrence." Conversely, "small" corresponds to lack of effect on deterrence. Unfortunately, "deterrence" also is ambiguous unless used in a totally generic or quite specific sense; and this is not usually the case.

What type of civil defense might conceivably be developed which is "large" in this sense? Since there is no evidence that Soviet civil defense has had any effect on U. S. strategic planning or weapon procurement, apparently Soviet civil defense is not "large," even though much larger than the U. S. system in terms of the cost relative to the total defense and budget. Further, when examples of systems that are supposed to affect deterrence are given, they are apt not to feature size so much as procedures for development or use, viz., a "crash civil-defense program," or use of "strategic evacuation" of cities.

Thus the existing system certainly cannot be called "large" by any reasonable meaning of that term. But calling it "small" means very little because that term covers several orders of magnitude of cost, and in terms of deterrence covers every system in existence or planned today, with the possible exception of the Russian system for evacuation of cities.*

* See Appendix I.

Civil Defense and Active Defense.

Perhaps the most obvious of the connections between civil defense and other defense systems is the coupling with ABM systems, particularly one deployed to protect the population. In general, it appears that civil defense and ABM systems are complementary;[33] the former does not significantly decrease physical damage from nuclear attack; the latter appears to require the former as backup, unless the assumption of total effectiveness is made.

In early studies, the deployment of an ABM system about a metropolitan area was assumed to require a complementary fallout-shelter system within the area.[28] This assumption was based on the possibility that an enemy would attempt to avoid the ABM system by directing his attacking missiles to ground-burst outside its effective range, and, hopefully, upwind of the city, thereby causing heavy fallout in the metropolitan area. This argument has since been criticized on the grounds that such an attack depends on uncertain wind directions and on technical problems of missile targeting which make it an alternative very unlikely to be taken seriously by an attacker.[34]

Deployment of an ABM system around cities may require a prompt-effects shelter system as backup, due to the expectation that multiple air bursts in the vicinity of a city would produce fire and blast effects, possibly of fairly low magnitude, but hazardous, nevertheless. This type of coupling has not been given much study.

ABM systems can affect civil defense secondarily through changes in the size and pattern of a nuclear attack on this country: 1) it could, as has been argued, result in a net change in the size of an attack, which would be increased to overpower the active defense; 2) it could change the size of the attacking missiles, making some of them less powerful to permit inclusion of penetration aids or modification to incorporate multiple warheads, and possibly making some of them larger to be effective at greater distances from the target; 3) it could bring about major alterations in the targeting of the weapons, and in the time sequence of the attack.

All of these connections between the two systems indicate that if the ABMs are deployed to protect the population, they and civil defense should be treated as parts of a single system. Whatever modification of the enemy's attack size and pattern that resulted from ABM deployment would probably affect the shelter criteria considered desirable in different locations.

Clearly a major study should be undertaken of the implications for civil defense of the different types of ABM systems, particularly of the current plan to protect the retaliatory-missile silos rather than the population.

Civil-Defense and Older Military Systems.

The coupling of civil defense with older elements of the defense establishment has several aspects worth mentioning.

Since civil defense is not one of the classic missions of this country's armed forces, U. S. military men have historically tended to avoid involvement with civil defense, and to have little operational interest in it.

This tendency is reinforced by the nature of civil-defense operations, which are mostly under direction of state and local authorities, except for national intelligence programs such as warning. Assistance by military forces in civil-defense operations follows guidelines which preserve the identity of the military command; hence integration of civil defense into the military establishment has not occurred and probably will not. This emphasizes the manpower problem discussed earlier, and also seems to make OCD's position in the Department of the Army somewhat anomalous.

The connection with military reserves has been touched on. The problem which appears to require closest study is the relationship between civil defense and the National Guard (before it is federalized.) Both are being increasingly called upon to act together in peacetime disasters; and both would undoubtedly be used in a nuclear disaster. Further, both are civilian and subject to state law, and in operation are complementary. The relationship between the two should be clarified in connection with the problem of federalization of the guard, and also in connection with the problems of maintaining civil-defense operational capability at a level consistent with the magnitude of nuclear-attack-generated problems.

Civil-Defense Effectiveness.

Attempts to develop information on effectiveness of specified civil-defense systems and their effect on national recuperability contains uncertainties because of the lack of knowledge concerning (1) the nature and size of the attack; (2) the effect of an attack on complex systems; (3) the efficiency of shelter use; and (4) the problem of omitted effects.

It is sometimes argued that so many imponderables are involved that building any civil defense system is a gamble with too low a probability of "success" to warrant the expenditure.[28] We do not believe this. The following observations bear on this problem:

1. The range of possibilities for the nature, size, and consequences of an attack are unpredictable but are subject to study. Such studies form the traditional basis for the development of all military countermeasures. Civil-defense countermeasures can and should be similarly studied, the more so because the stakes are so high, in event of any attack.

2. The problem of damage to complex systems -- e.g., the petroleum industry -- is of major importance. The usual assumption is that first-order effects on these systems correspond to damage suffered by separate elements of the systems; this is the dominant type of study performed to date. Interactions between the elements are certainly suitable topics of research for ecological systems, economic systems, meteorological and climatic systems, and even social systems. Presumably, continued research to identify elements and comprehend interactions is justified and possible. Incompleteness is not a sufficient basis for rejection of results of the damage-assessment studies.

3. Efficiency of shelter use must depend on (a) warning time locally; (b) civil-defense operational competence locally; and (c) the state of public information locally. It would certainly vary from one community to another; in regions far from burst points there seems to be no reason why high efficiency should not be assumed even with the present civil-defense capability. Estimates of how dependent the capability for reaching shelter is on warning time in different types of communities could be obtained from prototype operational systems, even if rather small numbers of people were involved. It appears that this question is not so much imponderable as insufficiently studied. Several suggestions to improve the movement to shelter are being considered.

4. One can never be certain that major effects, important elements of complex systems, or dominant relationships have not been overlooked or given too little weight in the studies that have been made. Continuing criticism of the coverage implicit in studies of nuclear-attack consequences is extremely important; and this emphasizes the importance of candor and openness in discussing inputs into these studies.

<u>Preattack Aspects of Civil Defense</u>.

It is sometimes stated that a large civil-defense program would have an undesirable effect on the arms race by forcing an opponent to develop a counterprogram which would re-establish the hostage-population situation, thus causing an increase in attack size. It is also said that a large civil-defense program would make a U. S. first-strike tactic more acceptable by enabling the populace to conceive of absorbing the opponent's second strike, the net result being an increase in attack probability by an enemy fearful of attack by this country.[32] The plausibility of such arguments depends on the assumption that physical destruction, which is

independent of civil-defense protection, and civilian casualties can be reduced to the point of public acceptability. No such level of effectiveness appears likely to us.

We have already noted that the main question which such arguments raise has to do with procurement policies and with international policies of an opposing country. This question is subject to investigation and should receive it. As stated previously, the civil-defense measures of the USSR have had no significant effect on our plans.

Despite the observation sometimes made that a great deal could be accomplished two weeks before an attack during the build-up of pressures, it should be stressed that the system is complex, the educational problems enormous, and the best opportunities for shelter production are those which take advantage of new construction and which proceed at a steady rate. The conclusion is quite clear: improvements of a civil-defense system require a period of years, not weeks. Except in periods of rapid build-up of international tensions, it will always be easier to argue against than for a civil-defense system that will cost a substantial amount of money and effort, involve many people, infringe on some privileges, and all to generate only partial protection against nuclear attack of unknown probability. However, a case for such a system can be made.

Education and Training.

The history of civil-defense education is summarized earlier, and it is pointed out that OCD Staff College courses are intended for the general public, while for the specialist, there are architectural and engineering courses, some at universities, many of them sponsored by OCD.

The effectiveness of civil-defense training and education of the public must be judged quantitatively as well as qualitatively. With regard to the numbers being educated, the results being achieved are perhaps an order of magnitude below minimum requirements even for a trained reserve of personnel for immediate postattack operations. What is needed, we believe, is a more far-reaching educational program, probably at the high-school level, on weapon effects, countermeasures, civil-defense operations, etc. Also needed is a nationwide training program for police, firemen, the National Guard, etc., to ready them for roles in the civil-defense system.

Improvements in the OCD-sponsored engineering education could probably fulfill architectural and engineering and research requirements for fallout-shielding education. But prompt-effects shielding offers major educational problems due to the variety of effects. For example, it would be possible in principle to broaden the existing shielding courses to incorporate blast, fire, missiles, etc., but this is not a trivial change, particularly when the course is given in an engineering department

little concerned with, for example, blast-wave physics. Similarly, it would probably be possible to give greater emphasis to prompt-effects protection in the OCD Staff College courses. However, the problem of prompt-effects shielding may be primarily one for city planners, architects, and consulting engineers.

Cost and Cost Effectiveness.

Cost, like many other aspects of civil defense, is hard to discuss without reference to specific program types; and these have seldom been clearly stated. Three levels of shelter-system costs exist: 1) fallout shelters, generated by slanting of designs in new construction at about $15 per space; 2) prompt-effects shelters similarly generated by slanting at a cost of perhaps three to five times that of fallout shelter, say $50 per space as suggested by European experience; and 3) high-protection systems such as the tunnel-grid system,[35,36] or certain classes of shelter in Switzerland and Sweden, with costs from five to ten times higher again, say $300 to $500 per space. (Swedish experience indicates that this last figure may be too high.[37]) Similarly, operational systems involving professional staff and paid reserves must be considered. Combinations of the preceding are estimated to cost from one to several percent of the total defense budget in European countries, and would presumably cost about the same, perhaps slightly less, in this country.

That is to say, a 10-fold increase in defense allocations for civil defense would result in an effort about one percent of the size of the present DOD budget, and this could permit the carrying out of a full fallout-shelter program, of a comparable program of prompt-effects slanting for metropolitan areas, and of the development of a program combining professionals with paid reserves in a far more realistic civil-defense operational capability than currently exists.

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COMMENTS, RESERVATIONS, AND DISSENTS OF COMMITTEE MEMBERS

COMMENTS, RESERVATIONS, AND DISSENTS OF COMMITTEE MEMBERS

Critique as a whole.

The Critique contains a large number of individual statements and ideas with which I agree. But, as a means for providing constructive suggestions for future civil-defense programs, the Critique has two glaring weaknesses: 1) the individual components, apparatus and operations of civil defense are not viewed as interrelated parts of a civil-defense system and therefore no means are provided to a reader for evaluating the relative worth of the many, apparently unrelated, suggested changes in policy, research, operations, and so on; and 2) the emphasis is highly asymmetrical, perhaps because of the non-systems approach, in which prompt-effects research and shelters are given tedious, repetitive attention and postattack-recovery problems are only occasionally and briefly mentioned. Whereas rough estimates of the effort and costs of a postattack-recovery program (research plus operations) needed to assure avoidance of obvious recovery bottlenecks and secondary casualties in conjunction with the expected performance of the "full fallout shelter" program indicate an outlay almost equal to that for the present shelter program, no allocation of such an outlay has, to this date, been proposed for a postattack-recovery program of any significance. Yet the thrust of the discussions in the Critique suggest even more emphasis be placed on saving lives from early weapons effects with no equivalent or corresponding emphasis given to the means for keeping the additional survivors alive. The qualifying statements in the document concerning the reasons that the postattack-recovery problems are neglected do not offset the effect of the neglect of these problems on the reader who may wish to seriously use the Critique to make an evaluation of the overall technical status of and future requirements or justifications for the civil-defense program.

Carl F. Miller

Critique as a whole.

I really have been very depressed by the schizophrenic division of our defense efforts into "active" and "passive" systems. What the country needs is not only a civil and military defense system, but a total defense system, the objectives of which are to maximize immediate survival and to minimize the recovery time of the nation following a nuclear attack.

It seems to me this requires:

1. A nationwide public and private shelter system mostly to save people, including adequate, planned protection for medical and paramedical personnel along with those trained in other key professions and competencies;

2. an antiballistic-missile system mostly to save or minimize damage to the nation's key institutions, facilities and the "tools" of critical industries as well as to help save the population; and

3. a stockpile of food, medicine, and other necessities, strategically placed, to make recovery possible and to ease a delay in recovery activities in those areas where delayed effects prove a persisting problem.

Clayton S. White

Critique as a whole.

The following should be included in "Major Conclusions and Recommendations" and at the end of Part III:

> It is the risk inherent in the existence of nuclear weapons without effective international control which makes civil defense a necessity. Attempts to base major civil defense policies on supposed psychological effects of particular weapon systems on potential enemies, or on supposed strategies of particular foreign powers, are not likely to be adequate and are questionable also for another important reason. It is becoming clear that civil defense preparation takes a very long time compared to the life cycles of weapons and counter-weapons, strategies and counter-strategies. Effective civil defense must literally be built into our buildings, cities, transportation and communication systems, food and energy supplies. It must therefore be built into our governmental structure in a way which is insensitive to the comings and goings of weapons and strategies. Only the effective abolition of the possibility of nuclear attack can remove the need for this protection.

Joshua Z. Holland

Critique as a whole.

There are two principal points which I miss and which I would emphasize more strongly. First is a clear statement of the need for more emphasis on rural civil defense in the U. S. civil-defense program, rather than abandoning all effort in that area. The latter course would be most regrettable, partly because inexpensive defense, such as fallout shelters, can be most effective in rural communities and partly because the rural communities' role is the most important one in any postattack period.

The second point I would like to emphasize more refers to the problem of the evacuation of cities. The Little Harbor Report opposed nationwide evacuation of U. S. cities because such an action might be provocative. It is now apparent, however, that USSR civil defense gives prime emphasis to plans for evacuation, and the question comes up: how can we protect ourselves from the adverse effect of a full-scale Soviet evacuation of cities, followed by an ultimatum? The simplest, effective way would be to have plans ready for counter evacuation, i.e., plans to evacuate our own cities if and when the cities of the USSR are evacuated. I realize that there would be strong criticism and opposition to such a proposal, but it is probably the only practical way we could respond to the evacuation of cities in the USSR.

Eugene P. Wigner

We believe too much emphasis has been and is still being placed on federal financing of protective construction. Other than for shelters in federal buildings, European countries have avoided federal financing by making incorporation of appropriate shelters into new construction a requirement. Past emphasis on federal financing has resulted in overemphasis on public shelters and inadequate development and dissemination to the public of construction information for private shelters. That past emphasis has been carried over to this Critique is evidenced in the omission of private shelters from the discussion of shelter programs in Part I.

While we agree that federal financial support would be required to provide adequate protection for an appreciable portion of the population on a short-time scale, we believe that too much emphasis has been and still is being placed on federal financing of protective construction, that dedication to federal financing constitutes a limitation not mentioned in the first recommendation, and that past emphasis on federal funding has been carried over to this Critique. In view of past reluctance by the Congress to provide funds for shelter construction, in view of the difficulty of establishing a defendable time scale by which a specified level of protection should be achieved, and in view of competition with other national goals, we believe it is unlikely that any substantial federal shelter-construction program would be undertaken until events make the need indisputable and until there is time only for inadequate expedients. We are convinced of a need for the federal government to embrace alternate measures which would require little, if any, direct federal appropriation. We are convinced that a presidential statement supporting such measures is necessary and that the statement should be made in the context of a long-range goal rather than with respect to any particular emergency. Alternate measures might include: 1) Development and dissemination of plans and specifications for a spectrum of private single- and dual-use shelter designs in keeping with variations in local need and with options spanning a range of costs. 2) Promotion of national legislation similar to that of several European countries which requires shelter meeting federal standards to be included in all new construction. 3) Promotion of legislation which would provide ad valorem tax exemption for single-purpose shelters.

Such a program could provide shelter for the population within a generation and has the inherent advantage that it can be reoriented at any point in time to accommodate changes in weaponry or targeting options.

Luke J. Vortman

(Endorsed by Clarence R. Mehl
and Clayton S. White)

Major Conclusions and Recommendations, Page 4.

We can endorse this recommendation only if responsibility for civil defense is removed from the Department of Defense. A better balance between active and passive defense is required for an adequate defense posture. Experience of the past few years suggests that the Department of Defense is too preoccupied with active defense to treat passive defense in an equitable and impartial manner, so it seems even more improbable that the Department of Defense would give adequate attention to nonmilitary emergencies.

Luke J. Vortman

(Endorsed by Clarence R. Mehl
and Clayton S. White)

Part I: Research, Operations and Future Extensions of Civil Defense, Page 13.

Another alternative is a professional force of paid military retirees with obligatory assignment to civilian positions in a civil-defense force. Such a force probably would be immune to diversion to active military service.

Luke J. Vortman

(Endorsed by Clarence R. Mehl
and Clayton S. White)

Appendix II: Organization and Operation of Civil-Defense Systems.

The Subcommittee on Organization and Operation of Civil-Defense Systems, as recorded in Appendix II, falls short in expressing the hard, direct, serious recommendations of the Subcommittee. Therefore, as a member of the Subcommittee, I request that this statement be included under a section on Comments, Reservations, and Dissents of Committee Members. Accordingly, I recommend:

1. Remove OCD from Department of Defense/Department of the Army.

2. Create a new organization combining OCD and OEP and interrelating it to the state and local governments. This new organization to have a broad, coherent, long-range, comprehensive program oriented to on-going emergencies and preparation for nuclear attack.

3. Provide the new organization with legal status and authority to administer a program which is designed to protect the populace, maximize life-saving rescue and care of people, limit property damage, maintain and quickly institute an organized society capable of meeting the needs of its members while preserving its basic values.

4. Charge the new organization with responsibility to develop a coherent command and control structure that will be responsible to national, state, and local authorities and will have legal responsibility for eliminating inter-jurisdictional disputes.

5. Establish national, regional, state, and local sensors and data-receiving centers that exchange daily critical facts, trends, and tensions on all events that could lead to disaster. Record in advance predictable events that could cause crises and develop plans to meet them when and if they should occur. Maintain a constant service to answer unexpected, unanticipated, and non-routine questions.

Stephen R. Tripp

A P P E N D I X I.

F O R E I G N

C I V I L D E F E N S E

(A COMPILATION OF AVAILABLE INFORMATION)

APPENDIX I. FOREIGN CIVIL DEFENSE*

The approach in the United States to protection against the hazards of a nuclear attack differs substantially from that which has developed in the different countries of Europe. One may ask why the civil-defense establishments in so many European countries contain elements clearly compatible with civil-defense requirements in the United States, but which have not been developed here. In a general way, this might be attributed first to the fact that the United States has not had to protect its citizens under enemy attack; second to the powerful army, navy, and air force traditions of deterrence and attack; and third to governmental decentralization as expressed in the joint federal-state civil-defense balance of authority.

In contrast to U. S. emphasis on fallout shelters and local responsibility for emergency operations, other countries, especially in Europe, consider prompt-effects shelter essential, and tend to rely on large standby civil-defense forces procured through national conscription, organized into mobile teams, and trained in providing emergency services.

Among the non-Western-European nations, the Soviet Union may have the most comprehensive civil-defense system in existence today, although there are many gaps in our knowledge of it. Details, including some that are only presumed, are given later in this appendix.

Among all foreign civil defense, that of Israel is of particular interest since it has been tested in the 1967 war, though not, of course, against nuclear weapons. But against conventional artillery and bombs it was quite effective, particularly in the speed and effectiveness with which it was mobilized for actual use: shelters were readied, people were warned and shepherded to shelter, and shelter management established, all within hours.

Like the U. S., both Australia and Canada concentrate on fallout protection. Canada has completed a fallout-shelter survey; Australia is conducting one in major cities.

Elsewhere in the world, it can be noted that Cyprus has a civil-defense law and has just issued a compulsory civil-defense service order in September 1966; the office of civil defense of the Dominican Republic began in 1967 to designate shelter in 11 provinces; in New Zealand the civil-defense act of 1962 provided for civil defense beginning with the

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* Except for the summaries on the USSR and on Finland, this Appendix is based on material supplied by the Office of Civil Defense (OCD).

national, regional, and local levels for all types of emergencies and disasters; in the Philippines, civil-defense laws and a civil-defense organization have been established; there has been, over the years, several requests from the Philippines for materials from OCD and, more recently, for samples of shelter survival crackers and radiological instruments, indicating an active civil-defense program; the review and updating of Thailand's civil-defense law is under way, but little is known of any actual accomplishments.

In 1962, the fifteen member nations of the North Atlantic Treaty Organization, through its Civil Defense Committee, adopted a resolution which emphasized that protection from the effects of fallout is the most promising measure, within limits of available resources, for saving lives. Since that time, several member nations have followed the U. S. example and have either undertaken or are now conducting pilot surveys, or regional or nationwide surveys, to determine what fallout protection is inherent in existing structures.

Legislation or regulations providing for public, private, and/or industrial shelter exist in Austria, Belgium, Denmark, Finland, Germany, Iceland, Netherlands, Norway, Portugal, Spain, Sweden and Switzerland. Switzerland and the Scandinavian countries, in particular, have extensive shelter programs, including both blast-proof and fallout-resistant structures, provided through federal financial assistance.

All the countries have a system for warning against attack, and most of them have, or are in the process of establishing, a fallout-detection and reporting system. Some have also supplementary radio-warning networks.

Brief summaries of the status of civil defense in the USSR and in several of these European countries are given below:

SOVIET CIVIL DEFENSE*

In October 1967, the Soviet government passed the Law on Universal Military Obligation, Article Seventeen of which calls for compulsory civil-defense instruction in Soviet schools. A fifteen-hour-a-year civil-defense training program was introduced in 1967-68 in all fifth, sixth, and seventh grades of the Soviet schools, and a thirty-five-hour program in all ninth grades. Thus, the civil-defense program is beginning to involve every citizen; its organization reaches into every region, city, village, collective farm, and industrial establishment.

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* This is a summary of an article written by Mrs. Joanne Levey, Oak Ridge National Laboratory (ORNL), for publication in the magazine "Survive."

Preattack evacuation of large segments of the urban population to rural areas is planned in detail for certain conditions of crisis escalation. Thus, industrial workers in cities would remain on the job and take refuge in shelters at or near their place of work, while nonessential workers and retired people would be transported to the country where they would assist their rural hosts in constructing hasty fallout shelters on sites that have already been surveyed for this purpose. There are detailed plans that include when and where each employee of a plant would go, where he would be billeted, how food supplies would be increased in evacuation areas, and even how mail would be forwarded to him. Soviet strategists conclude that after evacuation and dispersal of their urban population, losses, on the average, would be eight to ten times lower.

There are numerous types of shelters: subways equipped with heavy blast doors; substantial, isolated, single-purpose shelters; basement shelter in apartment housing and public buildings; and possibly some useable space in mines. Large public shelters are equipped with heating and ventilating systems with filters for keeping out radioactive dust, and chemical warfare and biological warfare agents. There are radiation measurement instruments, portable radios, and emergency exits.

How effectively the Soviets could protect their urban population from nuclear weapons, either through urban shelters or preattack evacuation to rural areas, is not easy to determine. But, should war occur, there are important goals that they might well approach: the maintenance of morale, the prevention of panic, and the knowledge of how to make the best use of the available warning time.

SWEDEN

Construction of shelters is provided for by federal law; they must provide protection against both prompt effects and fallout. Private shelters are required in all new apartment houses of more than two stories that accommodate more than 25 residents, and are in towns of more than 5,000. These shelters are reinforced concrete bunkers in basements. The law also requires shelters for factories, schools, and hospitals. Shelters must provide 7 to 15 psi protection (depending on location) and withstand building collapse; initial radiation must be reduced to 200 rems or less. There is federal subsidy for constructing private shelter. There also is a program for the construction of large, dual-use public shelters with 70 percent of the cost coming from federal and 30 percent from municipal funds. They provide 15 to 45 psi protection, with at least comparable protection against initial ionizing radiation. The large rock shelters, which have received considerable publicity, are capable of withstanding 140 psi.

Spaces for 2.3 million persons were completed in 1966, and the number is increasing at the rate of 200,000 a year. As of 1966, completed shelters, both private and public, provided sitting space for three million people.

NORWAY

The Norwegian Civil Defense Act of 1953 requires that municipalities build, equip and maintain public shelters, for which two-thirds of the cost is borne by the central government. According to building regulations, private shelters are constructed in all new buildings of a certain size (apartments, houses, churches, hotels, theaters, industries) at the expense of the owner. As of September 1966, there were 150,000 public and 600,000 private shelter spaces.

In Norway all fit men and women between the ages of 18 and 65 not subject to military service (about 7 percent of the male population) are required to serve in civil defense, either in local organizations or in mobile columns; 14 of the latter are maintained in the country. These are rescue teams equipped to effect rescue under conditions of blast and fire damage, and ionizing-radiation exposure. Local personnel receive 20 hours of refresher training every third year. Norway as well as Sweden has detailed standby evacuation plans for their larger metropolitan areas.

DENMARK

In Denmark, as in Norway, there exist federally financed programs of public-shelter construction in major areas against both prompt effects and fallout. Private shelters are compulsory in new buildings having more than two apartments. These must provide both fallout and limited blast protection; they are built at the owners' expense.

By 1968, the public shelters, which are built by the central government, provide space for 250,000 persons. Private shelters raise the total to approximately 1.4 million spaces. In addition, all industries employing more than 75 persons at a single location must provide protective measures.

WEST GERMANY

A comprehensive and complete shelter law was passed in Germany in June 1965. It provided that, beginning in July 1966, shelters must be built in all new buildings, including houses, industrial concerns, schools, and educational and professional training establishments. These must give protection against falling debris, fallout, and the effects of fire, and biological and chemical warfare agents. A degree of blast protection is required in areas of possible combat. Subsidies and tax benefits are offered by the federal government. Certain financial benefits are also available to owners of existing buildings who construct shelter areas. Subsequent actions of the Parliamentary Budget Committee have, however, postponed the implementation of this and other civil-emergency planning laws.

In West Germany, the Civil Defense Corps is made up of volunteers -- about 35,000 in 1963. In September 1965, a Civil Defense Corps law was passed providing for compulsory service of 10 years. Men between the ages of 18 and 65 not required for the Army and women between the ages of 18 and 55 were to be subject to conscription. A force goal of 200,000 was forecast. However, the 1965 law has not been implemented. The Civil Defense Corps is organized into mobile units with firefighting, rescue, medical care, radiological monitoring and communication capabilities.

GREAT BRITAIN

Great Britain has announced a reduction in civil-defense activities and expenditures for the fiscal year 1968-69. The following are to be retained: the Warning and Monitoring Organization, including the Royal Observer Corps, but with some reorganization and reduction; maintenance of existing control centers and their equipment (with a 75 percent civil-defense grant), as necessary to prevent their deterioration; and storage (costs also eligible for a grant) for certain equipment and instruments until they can be stored or disposed of. Local recruitment for civil-defense work, recruitment to the Civil Defense Corps, Auxiliary Fire Service, Ambulance Reserve, civil-defense training and nursing, and related exercises are to be suspended. One of the three training schools, at Easingwold, will remain open and provide courses for senior officers of central and local government, and instructional courses designed to enable local authorities to maintain a nucleus of instructors in civil-defense techniques. In this manner, local authorities are to be kept informed of any changes in policy and any new developments in civil defense. Planned expenditures are being reduced from £ 25 million to about £ 13 million for 1968-69, and in the future to reach approximately £ 7 million annually.

SWITZERLAND

The Swiss consider that the nuclear threat to them could take two major forms:

1. MT weapons might be used against target points in surrounding countries and therefore fallout might be the primary effect to protect against.

2. If a belligerent wished to move his forces through Switzerland, he might use KT weapons to clear a passage, and therefore there is a threat from prompt effects, without fallout, from such weapons.

In Switzerland, all new apartment structures are required by law to provide shelter for all inhabitants of the building. They must protect against all the prompt-weapon effects associated with overpressure levels of 15 to 45 psi; they must also be capable of resisting associated debris loads and provide protection against associated fallout. Hospital shelters must protect against 135 psi. There are also shelters in sides of mountains, and there are shelters derived from underground parking garages. Management of the large community shelters is provided by the Swiss Army.

Switzerland mans its civil-defense organizations by using the approximately 20 percent of the candidates in its universal military service who do not qualify for Army duty. These young men, 18-20 years old, serve on active duty for two years and in the active reserve until age 50. While in the reserve they must serve three weeks of active duty per year. Retired Army personnel between the ages of 50 and 60 also are required to serve in civil defense, if physically able. Women may volunteer for five years.

Swiss civil defense is highly organized. Local governments are responsible for operations at home, or to assist neighboring jurisdictions. Help may be requested of the commune which has trained mobile units to dispatch. Communes in turn may request military assistance from the cantons. Special troops for civil defense have heavy equipment for firefighting, rescue, and medical assistance.

FINLAND*

In Finland, civil defense comes under the Ministry of the Interior. Builders are required by law to include shelters in all new buildings, at an estimated incremental cost, to the builders, of about two percent of the total building costs. Thus, about half the total cost of civil defense -- an average of over $12 million annually since 1960 -- is borne privately.

Besides shelters in new buildings, Finland has massive steel-doored shelters, dug out of bedrock (25 in Helsinki, alone). Some date back to World War II; some are dual purpose (e.g., leased to private businesses); some hold as many as 10,000 people; most of them are equipped to permit a sealing-off period of six hours. The federal government also constructs control centers throughout the country.

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* Based on a UPI article printed in the New York Times, April 16, 1969, page C15.

There are 98 permanent civil-defense workers; there are 215,000 volunteers already trained; Finnish law requires that citizens do civil-defense work if called.

The Finns reason that it is very improbable that Finland will be a primary target, and that attack warning, in the form of attacks on other nations, will permit the accomplishment of these essential tasks:

1. Clear dual-purpose shelters of their peacetime businesses.

2. Inform the population of the locations of shelters.

3. Advise people to bring food, bedding, etc., to shelter.

4. Mobilize the trained civil-defense volunteers.

5. Conscript additional civil-defense workers if needed.

APPENDIX II.

ORGANIZATION

AND OPERATIONS OF

CIVIL DEFENSE SYSTEMS

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APPENDIX II. ORGANIZATION AND OPERATION OF CIVIL-DEFENSE SYSTEMS*

INTRODUCTION

The ability of the United States to protect the populace from nuclear attack -- to maximize the number of lives saved, to limit damage to property, and to maintain or quickly reinstitute an organized society capable of meeting the needs of its members and of preserving its basic values -- depends heavily on the effectiveness of civil-defense organization and operations in the preattack, transattack, and postattack periods.

The effort to achieve an effective state of preparation for nuclear attack during peacetime, however, faces some formidable personal and organizational obstacles, especially when the threat of such a disaster seems remote or uncertain.

> Programs designed to prepare people for uncertain disaster must compete with immediate and pressing human concerns -- the day-to-day problems of earning a livelihood, protecting oneself and family members from the daily dangers to life and health, and securing recognition, response, and status in relations with members of one's personal community. This unequal competition is inherently unfavorable to communications and activities oriented to the uncertain future rather than the present. This is especially true when the future conditions are painful to contemplate, when there are no present rewards for the personal costs and sacrifices involved in making preparation, when there is no way of realistically testing whether the preparedness measures are effective, when there seems to be time before one must make a decision, and when there is no apparent way to come to grips with the problem by use of present resources or manageable units of activity.[1]

This characterization of the personal obstacles to the achievement of adequate disaster preparations also applies in large measure to the local organizations that comprise the backbone of civil-defense preparation for nuclear attack. Such departments as the police, fire, public works, health and welfare are preoccupied with the immediate and pressing everyday needs of the community they serve, and with preparations for mitigating, controlling, and ameliorating the peacetime crises that they are likely to confront. From the perspective of state and local governments, the threat of nuclear war or other forms of enemy attack appears far less immediate and menacing than those dangers to

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* See section on Comments, Reservations, and Dissents of Committee Members.

life, safety, health, and property that are already present or that have a high probability of occurring in the near future -- rising crime rates, riots and civil disorders, environmental pollution, large-scale accidents, epidemics, and a wide variety of other natural and man-made crises and disasters.

These considerations provide the context within which the Subcommittee on Organization and Operation of Civil Defense Systems has examined present Office of Civil Defense (OCD) plans, programs, and research and development efforts pertaining to civil-defense organization and operations. The Subcommittee has placed primary emphasis on methods of improving the operational readiness of the civil-defense system, taking into account these and other obstacles and constraints that must be faced in the development of a realistic civil-defense preparedness program.

In the subsequent sections of this Appendix, the Subcommittee offers a number of comments, suggestions, and recommendations pertaining to various facets of civil-defense organization and operations. It will be noted that many of these provide detailed elaboration on the following more general observations, conclusions, and recommendations:

1. OCD plans, programs, and research and development efforts are predominantly oriented toward nuclear-attack conditions, rather than toward lesser emergencies. This is a reversal of the emphases and concerns of state and local governments, which are primarily oriented toward recurrent peacetime emergencies and crises.

2. Civil-defense activities at state and local levels, however, are not, for the most part, currently integrated into the ongoing, routine functions of these governments. Many civil-defense facilities, personnel, and equipments have great potential usefulness for routine governmental functioning, but the tendency in most communities is to view civil-defense activities as irrelevant to the day-to-day functioning of the government.

3. One major device for securing better integration of civil-defense functions into the ongoing structure of government is to relate nuclear-attack-protection plans and programs to the continuing efforts of national, state, and local governmental agencies to improve their organizational and operational capabilities to handle a wide variety of peacetime emergencies and disasters.

4. It is recommended that OCD broaden its focus of attention to include a "total spectrum" approach to crises and disasters; that it actively stimulate and encourage the utilization of civil-defense resources in all types of peacetime crises; and that it constantly relate nuclear-attack-protective plans

and programs to the existent capabilities for handling lesser types of crises. Such an approach would not only provide peacetime facilities and services of value to local communities, but would also provide useful training, an increased number of trained personnel, and an improved operational capability that would enhance the effectiveness of civil-defense operations under nuclear-attack conditions.

INTEGRATION OF CIVIL DEFENSE INTO LOCAL GOVERNMENT OPERATIONS

In a review of the OCD research program by the Advisory Committee on Civil Defense in July 1963,[2] a special group on behavioral sciences developed the following observations:

> The future public acceptance and continuity of an effective civil defense program is critically dependent on developing a close fit between civil defense operations and the ongoing, normal needs of society, both national and international. The research program should therefore address itself to the broad question of how civil defense can be built into the normal structure and thereby contribute to the continuous protection and enhancement of human life.
>
> All civil defense research should be oriented more toward the objective of devising civil defense programs, equipment and techniques that would be useful in peacetime. The approach should be a step-by-step rather than a crash program. It should start with existing social structures (e.g., police, schools, churches, armed forces) and build them up to give them civil defense capability.

Although OCD, since 1963, has moved in the direction of developing a greater degree of emergency operational capability for handling nuclear-attack conditions through its Emergency Operations Simulation Training, Community Shelter Planning, Military Support Planning, etc., it has not explicitly addressed itself to enhancing the capability of local governments to respond to all types of peacetime emergencies and crises.

Closer integration of civil defense into the structure of local governments is a problem of central research concern. Among others, the following points can be made:

1. Although the primary objective of civil-defense planning must still remain the protection of the civil population against enemy action in war, a secondary objective should be the development of improved competence in the management of lesser emergencies (e.g., natural disasters, civil disorders, etc.).

2. Unless a proved operational capability is established for these lesser types of crises and emergencies, civil-defense organizations are not likely to be fully utilized in the event of a nuclear-attack situation. Virtually all past research on domestic disasters and international crises indicates that decision-makers tend to turn to those agencies and personnel which have already demonstrated their capability to handle past emergencies.

3. The development of an operational capability for handling potential nuclear-attack conditions is critically dependent on aligning civil-defense interests and resources with the ongoing local concerns for public safety and for handling lesser types of emergencies. Municipal problems, insofar as they have a direct relationship to civil defense, are predominantly problems of emergencies <u>other</u> than thermonuclear attack.

4. The utilization of civil-defense emergency operational capabilities during lesser types of crises provides highly useful experience and training for the progressive improvement in these capabilities and also an opportunity to demonstrate the usefulness of civil-defense organization and systems.

In the light of these and similar emphases, there are many questions that require further consideration. Many are concerned with matters that are within the purview of the OCD, but a few are not.

Therefore the Subcommittee urges that the federal government consider the desirability of developing a more unified, integrated national preparation for and response to disaster in all forms -- natural, manmade, peacetime, nuclear. Among the methods considered for achieving this goal should be the recombining of the OCD and the Office of Emergency Preparedness (OEP).

At the same time, the Subcommittee recommends continuing study directed toward finding answers to the following:

1. What changes in OCD policy, statutory authority, and relationship with OEP would be required in order to shift emphasis to a total-spectrum approach to emergency organization rather than predominant concern with wartime nuclear-attack conditions? Would combining OCD and OEP be a satisfactory and sufficient solution?

2. What types of organizational devices could be developed at state and local levels to achieve better integration of all emergency functions? What are the problems of achieving close relationship between those levels and OCD? Would it be feasible and desirable to vest civil-defense responsibility in a single centralized office -- e.g., a Director of Public Safety or Coordinator of Emergency Activities?

3. How can the Civil Defense Emergency Operating Centers (EOCs) be utilized most efficiently in handling various types of peacetime crises? Should the Emergency Operations Simulation Training Program include specialized training of local officials in handling peacetime disasters and civil disorders?

4. What actions can be taken by federal, state, and local civil defense agencies to provide a more coherent, unified direction and control capability for local authorities? What lessons can be learned from the operation of civil defense in the recent racial disorders and in other similar emergencies?

5. What lessons can be derived from the study of recurrent crises and disasters for the operations of fire, police, and other safety forces during a potential nuclear-attack situation? (Note, for example, the new deployment and logistic tactics developed by fire departments and police departments as a result of the recent racial disorders.) To what extent are the tactics developed for such crises likely to be useful or dysfunctional under conditions of hostile external attack?

EMERGENCY OPERATIONS PLANNING

OCD efforts to enhance the emergency operational capabilities of local governments to deal with nuclear-attack conditions now rely heavily on the use of Federal Civil Defense Guides (FCDGs) and similar publications. In the area of emergency operations, the FCDGs have been designed to assist communities in preparing emergency plans on such subjects as Community Shelter Planning, Emergency Operating Centers, and Local Government Civil Defense Emergency Planning.

In reviewing these FCDGs and other OCD publications pertaining to emergency operations, the Subcommittee developed the following conclusions:

1. Current OCD guidance material is too weak in stimulating and encouraging the development of plans for emergency operations in peacetime disasters. Rather than saying merely that such plans "are recommended",[3] it is suggested that communities be strongly encouraged to develop plans and operational readiness for natural and man-made peacetime disasters.

2. The explanation of existing statutory, legal, and administrative limitations on the utilization of civil-defense resources in peacetime disasters is exceedingly ambiguous in current FCDGs and other guidance documents. It is recommended that these ambiguities be eliminated by specifying the precise conditions under which these resources can be used for peacetime purposes; and, if these conditions are too restrictive, that the changes needed to make the resources more freely available be developed.

3. The extent to which present FCDGs are clearly understood and can be used by state and local officials should be systematically examined. It is recommended that OCD conduct audience-research studies among the intended users of the guidance material to test reactions to the content and format of the documents and to determine their usefulness to the people for whom they are designed.

4. In addition to the printed materials designed to guide state and local governments, it is recommended that OCD take a much more active role in training and assisting state and local officials in their planning activities. To this end, it is suggested that OCD organize special field teams of experts on the various aspects of emergency planning and operations (fire, police, medical, welfare, public works, etc.) to assist local governmental and civil-defense personnel in developing their plans on site; and that other types of supplementary training programs for state and local officials be organized, e.g., summer institutes in which federal, state, and local civil-defense planners are brought together to assist each other in the planning process.

UTILIZATION OF CIVIL DEFENSE EMERGENCY OPERATING CENTERS IN PEACETIME

The over 3,000 Emergency Operating Centers now established or in the process of establishment in cities and counties throughout the U. S. provide protected facilities with communications, emergency power, and adequate space and equipment for effective direction and control. Although intended for enemy-caused disaster, the current OCD philosophy is that these centers "may be used during peacetime emergencies".[4]

The use of EOCs for coordinating and controlling municipal responses to civil disorders was recommended, in 1968, by the National Advisory Commission on Civil Disorders.[5] Subsequently, the Under-secretary of the Army authorized and encouraged cities to utilize civil-defense EOCs, communication networks, and trained auxiliary personnel in coping with civil disturbances.[6]

The usefulness of utilizing the EOC concept and communications equipment for monitoring and managing a wide range of community crises and emergencies on a continuous basis has now been demonstrated by the development of the Executive Command Center in the District of Columbia. This Center consists of a 9-room suite, located in the D. C. Municipal Center, that serves both as the permanent headquarters of the local civil-defense staff and as the Executive Command Center. The Center is manned 24 hours per day, 7 days a week by a permanent cadre of civil-defense personnel, which monitors the entire spectrum of potential crisis events and continuously keeps the Mayor and other key officials informed of happenings that may require special attention and action. Whenever the situation warrants, the Mayor and members of his staff move to the Center and the permanent civil-defense staff is augmented with liaison representatives from many different governmental and private agencies. Information from these various sources are converged and analyzed at the Center and the Mayor and his key officials utilize the information and communication resources of the Center in actively directing any necessary preventative, ameliorative, and control actions.

The Center was established to provide continuous support to the Mayor to ensure that the entire resources of the city are available to meet the needs of the people in all types of emergencies and crises. Its basic aims are threefold: (1) to prevent the occurrence of crises and disasters that threaten the public's safety, health, and welfare, wherever possible; (2) to forecast and make advance preparations for mitigating the damaging effects of such crises; and (3) to provide a mechanism for coordinating and directing the city government's protective, ameliorative, and restorative responses in the event that such disasters or crises actually occur. Thus the Center provides a highly useful model of how a local civil-defense organization can be integrated into the ongoing public safety, health, and welfare activities of a city, and thereby become accepted as the city's central mechanism for crisis-prevention planning and crisis management.

The fuller utilization of local civil-defense personnel, facilities, equipment and supplies for this type of continuous crisis monitoring is presently inhibited by statutes which limit OCD's responsibilities to enemy-caused attack on the U. S., and the correlative funding principle that replacement equipment for EOCs and personnel and administrative expenses must be justified in terms of their use for protection against enemy attack.[7,8] The fact that most state and local civil-defense organizations are not limited in the scope of their activities to enemy-induced attack conditions poses an awkward cleavage in the philosophies of the national headquarters on the one hand, and the state and local civil-defense agencies on the other. This results in the anomaly that innovative ideas on the utilization of civil-defense resources for peacetime and non-attack purposes tend to emanate from the lower levels of the civil-defense structure rather than being developed and encouraged by the national headquarters.

It is recommended that OCD examine its present statutory limitations with the view to seeking a change in its statutory authority that would eliminate this disjunction between national and lower level civil-defense philosophies and practices. It is also recommended that OCD conduct further detailed studies of the utilization of EOCs and other civil-defense resources for routine and peacetime crisis purposes and, on the basis of such studies, take appropriate actions to stimulate, encourage, and support this type of activity, and to issue clarifying directives on the use of EOCs for peacetime purposes.

EMERGENCY MEDICAL PROBLEMS

The Subcommittee is aware of discussions and studies in progress concerning the organization of emergency medical care.[9] In principle it seems desirable that integrated regional systems be developed for the operational management of emergency medical problems on a day-to-day basis and that these systems be capable of expansion to deal with increased numbers of casualties in disasters.[10,11] Such systems require at least a degree of integrated control of communications, transportation facilities, casualty distribution, and medical and paramedical personnel and facilities, and are dependent upon cooperation of many agencies. Several governmental agencies have begun cooperative studies or organization of emergency care.* Continuing participation of OCD in these studies should be encouraged.

Some of the Subcommittee's examination of emergency medical problems centered on the present Public Health Service packaged hospital facility and plans for its use. It was pointed out that the prevailing philosophy of attaching it to an existing hospital has been challanged on the grounds that if the hospital were damaged, the

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* An OCD representative states that substantial benefits can result from cooperation with other federal agencies to attempt to assure that their financial-assistance programs give due emphasis to both nonattack and attack emergencies. One such interagency approach is now in the formative stages as between OCD, the Public Health Service (PHS), and the Department of Transportation (DOT). This is to assure that expenditure of DOT funds for ambulance-dispatching operations and of OCD funds for EOCs are mutually supporting and beneficial. (OCD hopes to be able to work out arrangements with the Law Enforcement Assistance Administration so that their grants under Crime Control and Safe Streets Act of 1968 will, where applicable, have emergency readiness aspects included.)

packaged facility, and the staff to man it, would probably be damaged too. If the hospital were undamaged it is probable that the packaged unit would be used only to augment existing facilities. It was urged that further attention be given to risk-oriented siting of these units so that there would be greater probability that they would be available if regular hospitals are destroyed or rendered unusable.

CIVIL DEFENSE DIRECTION AND CONTROL CAPABILITIES

At virtually every level of the civil-defense structure (federal, state, and local) there are potentially serious deficiencies and gaps in the ability to achieve effective, coherent, coordinated action. At the federal level, OCD is not fully integrated into the national military command and control structure and intelligence community. The attempt to achieve unified action nationally in crises through the voluntary cooperation of state and local governments presents major direction and control problems. At present, the best that can be said is that there are a few of the rudiments for the development of a central direction and control system. Granting that these deficiencies derive from the inherent limitations of the present civil-defense statutes, inadequate funding, etc., OCD should continue to conduct further research on ways and means for developing a more coherent and responsive direction and control system -- a system more closely attuned to the rapidly changing events of modern society. The utilization of OCD communication facilities and operational capabilities during domestic crises and natural disasters provides one technique for improving the current direction and control system.

HAZARD MONITORING, FORECASTING, AND WARNING CAPABILITY

The responsibility for monitoring various hazards to the safety, health, and welfare of the U. S. populace, and for providing forecasts and warnings of real and potential dangers, is presently widely diffused among dozens of different governmental agencies. With respect to internal domestic hazards, for example, the FBI monitors evidence of sabotage, espionage, etc.; indicators of civil disorders are monitored by agencies such as the Justice Department; the U. S. Department of Transportation has purview over hazardous-materials-transportation accidents and disasters; the Federal Aviation Administration monitors the nation's airways for potential aircraft hazards; the Environmental Science Services Administration monitors the weather and various other natural environmental threats; and the Public Health Service Communicable Disease Center monitors disease threats and epidemics.

By utilizing the information derived from these and numerous other command, control, and communications centers, supplemented by information obtained from many other national public and private network monitoring and sensing systems (e.g., FAA pilot reporting system, communication company lines, power lines, fuel pipelines, etc.), it is possible to visualize the development of a centralized domestic hazard-monitoring, -forecasting, and -warning system which -- in coordination with the U. S. intelligence community, North American Defense Command, and the National Warning System -- would continuously cover virtually the total spectrum of potentially dangerous and hazardous events occurring throughout the nation.

Research studies of both international and domestic crises and disasters conducted during the past few years have consistently indicated serious deficiencies in the U. S. capability to bridge the gaps in emergency information needed for effective forecasting, warning, and protective actions. These studies have revealed that the necessary information for more effective precautionary, preventive, and protective actions is almost always present or available, but that there is a basic failure to share and coordinate the information among the relevant monitoring and operational subsystems. This failure largely stems from the fragmented responsibility and the relatively narrow perspectives of the numerous agencies that monitor the various types of hazards and dangers.

It is recommended that OCD, in collaboration with OEP and other concerned agencies, examine the possibility and desirability of establishing a centralized, coordinated national hazard-monitoring, -forecasting, and -warning system that would collate and converge information from the many different existing systems on a continuous, real-time basis. Such an examination would place central emphasis on the more effective collation and convergence of information that can be obtained from existing organizations and systems. More specifically, research on this problem would be directed to identifying (1) the primary sources of existing information on the various types of hazards, (2) the number of points of observation needed to provide continuous monitoring by type of hazard, (3) who needs the information, (4) how it can be disseminated most rapidly and effectively, and (5) the nature of the supporting organization that could carry out such an activity.[13]

VULNERABILITIES OF BASIC SYSTEM NETWORKS

The continued functioning of a modern, industrial society is critically dependent on the maintenance of such basic system networks as the electric power system; telephone, telegraph, and radio communications; transportation systems (railroads, highways, airlines, pipelines, etc.); water supply and waste disposal systems; etc. In

collaboration with OEP and other relevant agencies, OCD should review the adequacy of current knowledge on the vulnerabilities of these systems to internal breakdown, to sabotage, and to external attack, and insure that appropriate measures are being taken to protect these systems to the maximal extent possible.

Particular attention needs to be devoted to the vulnerability of the U. S. electric power system to sabotage and attack, of the means that can be used to minimize this type of damage, and of the effects that might occur in the event of a prolonged power outage. Although many critical civil-defense facilities are protected by auxiliary or backup power sources, the ability of these critical facilities and essential support activities to function under conditions of prolonged power deprivation should be reexamined. Further research is also needed on the backup power requirements for public shelters and public warning systems.

EMERGENCY CENTER PERSONNEL TRAINING

Realistic training exercises for emergency operations in nuclear war are inherently very difficult to contrive and to conduct. Even though current national training exercises, such as CDEX, have many deficiencies, they do reveal many weaknesses in the emergency operations procedures, e.g., messages are garbled or difficult to interpret; there is basic lack of understanding by the military of typical civilian responses to disaster; the military hierarchy often fail to recognize the importance of happenings on the domestic scene; and there are serious gaps in the information needed by decision-makers for postattack management of the situation.

With regard to their deficiencies as training exercises, the Subcommittee emphasizes that many aspects of the CDEX exercises are quite unrealistic because they do not take into account the false information, rumors, and ambiguity that commonly characterize most real-life crises and disaster situations. It is a mistake to exercise people with clear, clean-scripted inputs of information because they are likely to develop habits that will not pertain to a real-life situation. It is suggested that future exercises be made more real by introducing uncertain, false, and misleading information into the exercise script. It is also suggested that existing communication systems -- e.g., the 50-Governor-telephone-conferencing system -- be tested more fully in future exercises and that the postattack scenario should include simulations of numerous communication breakdowns and outages.[13]

INCREASED-READINESS MEASURES

The current OCD emphasis on the development of crisis-oriented operational measures, as opposed to developing a "ready-to-go" capability in the normal peacetime structure, should be subjected to searching and detailed research scrutiny. Therefore, OCD should continue and enlarge its support of research directed toward answering the following types of questions:[14,15]

1. What types and how many increased readiness measures can feasibly be accomplished at various elapsed time periods following strategic warning? For example, how many expedient shelters can be built and how many people trained in various types of skills in say, one week, two weeks, one month, three months, etc.?

2. Is there presently a sufficient quantity of trained personnel to accomplish the various elements of the increased readiness program in these (varying) time constraints?

3. What are the logistic requirements for increased readiness in various types of communities and areas? For example, are there sufficient building materials for construction of expedient shelters that are locally available, or would there be a requirement for the import of these materials from outside?

CIVIL-DEFENSE MANPOWER REQUIREMENTS AND AVAILABILITIES FOR NUCLEAR ATTACK

In a 1967 statement to the Director of Civil Defense, titled "Views of the Advisory Committee on Civil Defense on the OCD Research Program",[16] the following was said:

> It begins to appear that the most critical problems of operating civil defense or emergency systems relate to (a) the crisis availability of trained personnel, and (b) the requirements -- in different environments -- of trained personnel for effectiveness of the operations. The requirements can be enormously larger than the availability; and it appears to us that these two, and the relation between them, call for substantially greater research attention.

The Subcommittee on Organization and Operation of Civil Defense Systems has conducted several discussions of this topic, and it would appear from the information available that the crisis mobilization of manpower is a problem of central research concern for two reasons:

(a) the magnitude of a nuclear attack would require crisis measures which, to be effective, would involve virtually the entire population; and (b) no standby force, continuously maintained in a suitable state of readiness, can possibly be large enough to bear the full brunt of countermeasure requirements. Further, many or most of the countermeasures must almost certainly be taken by local people available at the time.

This leads to the posing of two questions about crisis mobilization: (1) What are the manpower requirements for mobilization of an effective countermeasure force to be active just prior to, during, and just after a nuclear attack? and (2) What are the existing manpower availabilities for crisis mobilization?

Research on manpower requirements would require further information on the operational requirements in relation to the nature of the hazardous environments and the injury spectrum that pertains in local areas.

Research on manpower availability must begin with the existing organizational resources -- (1) regular municipal and state forces for coping with natural disasters; (2) available military units and (3) local auxiliary personnel for fire, police, and other emergency services.

OCD officials have estimated that it requires 6 million trained people to conduct post-nuclear-attack emergency operations in the U. S., in addition to regular police, fire, and regular emergency personnel.[17] If we add the crisis-mobilization requirements and compare these with the availability of regular and auxiliary safety and protective forces (including 184,000 trained volunteer reserve police, 172,000 reserve firemen, 176,000 rescue personnel, some 100,000 shelter managers, and some 235,000 radiological monitors),* it would appear -- on an a priori basis, at least -- that the actually trained and available manpower may be over an order of magnitude short of the potential requirements.

If this assessment is approximately correct, it is apparent that OCD should be conducting further research both on the type of manpower requirements and on the techniques for recruiting and training additional local manpower to correct this deficit. One possibility for training additional emergency-duty personnel would be to have large and small industries and business organizations assume responsibility for training people in their own internal organizations, to be made available for general community use as needed. This idea should be given further attention. Further attention should also be given to the current ambiguities in the availability of regular force and National Guard

* OCD estimates as of June 1969.

personnel for civil-defense duties. Rational planning for manpower commitments cannot proceed on the basis of a "may-be-available-if-not-committed-to-military assignments" basis. It should be possible to secure the priority commitment of specific Continental Army and National Guard forces to civil-defense activities; if this is not possible it would appear wise to subtract these forces from the available manpower base and plan to train additional civilian reserves to replace them.

PILOT CIVIL DEFENSE SYSTEMS

The Subcommittee agrees that pilot models of civil-defense systems -- complete in the sense that they included the essential operational elements -- would provide extremely useful, and otherwise unattainable, information on manpower requirements, mobilization problems, training techniques, and the relationships between people, hardware, and procedures. The 5-city studies have been useful, in part, in offsetting the lack of a civil-defense system prototype, but they are oriented toward policy- and decision-making in civil defense, rather than toward increasing the actual operational effectiveness of civil-defense systems. Although the Subcommittee agrees that both these goals are desirable, more concern is felt over the undisclosed but suspected deficiencies in system operation. It is therefore recommended that the feasibility of establishing one or more pilot, civil-defense systems be examined in detail. These pilot systems should be representative of U. S. population, geography, and building-type patterns, and should include the appropriate hardware, procedures, and people to serve them.

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APPENDIX III.

BLAST

AND

THERMAL EFFECTS

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APPENDIX III. BLAST AND THERMAL EFFECTS

This discussion will be given under these main divisions: Blast and Associated Effects, Physical Response to Blast, Biological Response to Blast, Thermal Effects, Biological Response to Thermal Effects, and Biological Response to Combined Effects.

One of the major weaknesses in our knowledge of weapons effects concerns lack of information about, and the biological meaning of, the environmental variations expected at all locations where people are likely to be. Open (free-field) as well as a variety of non-free-field situations are involved, and individuals may be exposed to single hazardous effects from blast, thermal and ionizing radiations or to many of their possible combinations, depending upon exposure conditions. It follows that the tentative biomedical criteria available for separately assessing individual effects need to be extended and refined on the one hand and on the other hand, criteria should be developed for the many near-simultaneous and significantly separated exposures to various combined levels of all three major effects. It is true, however, that knowledge of synergistic and antienergistic effects* of combined injury simply isn't good enough to consider the biological responses together. As a result, planning is based on less than adequate knowledge of all the biological consequences even though the tentative criteria for individual effects are well enough advanced to be clearly usable -- if properly applied -- in many of the analyses needed to refine understanding of civil-defense needs.

The objective of this discussion is to give our evaluation of the state of knowledge, and to indicate what direction research programs should take. In some cases an indication of relative importance or urgency, as proposed by the Subcommittee, is also given.

BLAST AND ASSOCIATED EFFECTS

The subject of blast loading is subdivided into free-field effects and non-free-field effects from air bursts, near-surface bursts, and surface bursts.

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* Synergisms are combined effects in which the total effect exceeds the sum of the component effects. With antienergisms, the total effect is less than the sum of the component effects.

Free-Field.

Free-field blast phenomena for all three types of bursts are known well enough to make a start on Office of Civil Defense (OCD) programs. Included are weapon phenomenology in which OCD has a substantial interest but in which other Department of Defense (DOD) agencies and the Atomic Energy Commission (AEC) have the fundamental responsibility.

We conclude, however, that though OCD has been able in the past to rely somewhat on other agencies such as the AEC and the Defense Atomic Support Agency (DASA), OCD requirements haven't always been as well defined as they might have been. Also, other agencies, because of priority problems of their own, frequently could not be as responsive to OCD needs as desired. Therefore, all possible steps should be taken to strengthen liaison and communications among AEC, OCD, and other DOD agencies to the end that civil-defense requests are clearly stated and the problems of priority are candidly and seriously discussed.

Non-Free-Field.

Consideration of external loading of structures indicates that positional, orientational, and configurational factors are reasonably well known for simple shapes. These factors can be examined as needed for special shapes by use of a shock tube. Present information is not sufficient for adequately defining blast loading resulting from multiple reflections and channeling in dense areas of multi-story structures. There is some OCD need for additional information on such mutual blast shielding, as well as on debris production in similar areas of cities.

The Subcommittee noted that these needs constitute a low-priority item and that no work is currently being sponsored by either OCD or DASA other than the debris-production research at URS. In general, OCD should rely on the information that has been developed by other DOD agencies. OCD may at some future time require occasional specific refinements for specific applications; they cannot now be anticipated.

On non-free-field internal loading, some experimental work has been accomplished by Ballistics Research Lab,[1] and some analytical work by URS.[2] Also scattered information has been a by-product of specific projects carried out by other laboratories. More work is required. Experimental work on three-dimensional shapes should lead to an ability to describe interior blast environment in the detail required for biological experiments designed to abet hazard assessments. Results should be reduced to a form that would permit description of the environment in terms of size, shape, number of rooms, and of size, shape, number, and location of openings. Calculational models using two-dimensional shapes, when verified by agreement with experiment, constitute the most promising means of examining the wide range of parameters inexpensively.

The Subcommittee presently recommends strongly that OCD surveys be expanded in the design and analysis direction to provide the description of the protection from initial effects which is inherent in existing buildings that house National Fallout Shelter Survey (NFSS) spaces. It is vital that earlier recommendations of the Subcommittee* regarding determination of overpressure and dynamic pressure as a function of time inside buildings be given a high priority. The Subcommittee recognizes that the experimental work sponsored by OCD constitutes about 10 man-years of effort and that a calculational effort at about the two-man-year level is in preparation.[3] It is emphasized that this does not meet the needs envisioned by the Blast and Thermal Effects Subcommittee. It was the intent of the Subcommittee's recommendation that the experimental effort be increased and that the calculational effort be increased well beyond the two man-year level.

PHYSICAL RESPONSE TO BLAST

Physical response is discussed under four subdivisions: 1) structural types from the point of view of modes of damage and degree of resistance; 2) structural components; 3) debris production and translation -- by overpressure, wind, ground shock, and gravity; and 4) translation effects for both typical and atypical wave forms.

Structural Types.

To have OCD funds available for commitment to higher priority needs, research requirements for high (>15 psi) overpressures can be best met by turning to past work sponsored by DOD. For lower overpressures, additional information may be necessary in order to estimate blast protection inherent in existing structures, and to define the relationship between physical damage and casualties.

More specifically, Japanese data, together with information from recent laboratory tests at URS and other laboratories, need to be applied to U. S. types of construction. The NFSS shelter inventory should be examined to determine frequency of U. S. structural types as a first step step in developing a national inventory of structures with significant protection against initial effects. A level of 15 man-years per year for as much as five years might possibly be required. The Subcommittee recognizes that OCD is currently sponsoring a two-man-year effort involving an evaluation of NFSS basement shelters in existing buildings which will in part meet these requirements.

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* 5th Meeting, 17-18 October 1967.

Structural Components.

The concern in this area is the hazard from the flying missiles that result from the breaking up or breaking loose of such components as glass, panels, doors, etc.

Glass has been shown by experience to be an important cause of injury. While biological consequences of glass particles of a given size and velocity are still far from completely understood, there is equal or greater need for information about how glass missiles are produced. The Subcommittee has already recommended that glass fragment mass-velocity-frequency relationships be established as a function of blast overpressure, pane size, mode of mounting, and glass type and thickness.[4] Such information is necessary for casualty prediction as well as for evaluating the level of protection provided by existing NFSS shelters, many of which are above ground and in close proximity to glass. The necessity for similar studies extending to other frangible components such as doors, interior wall panels, and similar weak components was recognized. It was noted that in part this latter requirement is being met or can be met by project realignment within the four man-year effort currently being sponsored by OCD at the URS shock-tunnel facility.

Debris Production and Translation.

The objective of determining the missile characteristics of debris from various types of structural material has been only partially met. In particular, glass, frangible material, wood, plaster, masonry, and free-hung ceilings should be studied.

Efforts should be made wherever possible to obtain information on how debris is produced -- its kind, size, shape, mass, and velocity. With such information, missile casualties can be better quantified and protection provided by existing buildings better evaluated. Some of this information can be a by-product of work being done in the shock tunnel, provided plans are made in advance to collect the necessary information.

Translational Effects.

Experiments using dummies at the Nevada Test Site and at the Defence Research Establishment Suffield have led to a theoretical model for the typical blast-wave forms.[5] Non-ideal wave forms such as occur within buildings are not as well known. In order to estimate damage more accurately from direct as well as indirect effects -- i.e., missiles or whole-body translation -- there must be better understanding of the differences resulting from loading by typical (ideal) wave forms and atypical (non-ideal) wave forms such as are seen in and around structures.

Other Responses.

It is recognized that OCD currently is sponsoring about a one man-year effort to determine the significance of problems of soil liquefaction.* We think there is little reason to believe that this is an important enough item to warrant continuation.

BIOLOGICAL RESPONSE TO BLAST

Research on what happens to people under conditions of a nuclear attack has lagged behind the need with little or none of the work sponsored directly by OCD. Rather OCD submits requirements to DASA which sponsors and funds the research when priorities permit.** Regardless of whether OCD funds research separately or through DASA, the need will not be met unless the net result is an increase in the level of effort. The Subcommittee noted also that OCD benefits from much medical and biological research sponsored by other agencies; e.g., National Aeronautical and Space Administration, AEC, Public Health Service, DOD. The biological research requirements are broadly inter-related and long range, hence unsuited to the simple work-unit approach used by OCD for sponsoring other research. The Subcommittee recommends the continuing-research-program approach used by DASA and the AEC. The Subcommittee notes that efforts are necessary in the following areas:

1. Refine and complete tentative biological criteria for direct, indirect and miscellaneous blast effects including the little-studied factor of age, particularly for the young and old.

2. Determine the sequelae of blast injuries including those for impact.

3. Establish the quantitative significance of positional and situational factors on blast phenomena and the tolerance thereto.

4. Determine the effects of wave forms on biological response to blast-induced pressure variations.

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* URS Corporation: An Exploratory Study to Assess the Magnitude of OCD Foundation Problems.

** At present, a very large portion of the DOD nuclear-weapons-effects research and test effort and funding is devoted to the vulnerability and hardening of strategic offensive and defensive weapons systems, for the purpose of preserving the U. S. deterrent capability.

5. Refine and extend the intraspecies scaling studies for blast injuries.

6. Refine the aerodynamics of displacement events associated with both typical and atypical blast waves (disturbed wave forms) and determine the biological hazards that accompany the accelerative and decelerative phases of the translational process; viz., accelerative and decelerative impact, differential accelerative and decelerative effects on different body parts of the human body, etc.

7. Determine the overall significance of low-velocity, penetrating, frangible debris such as window and plate-glass fragments for clothed (trunk, arms, and legs) and uncovered (hands, face, and eyes) portions of the body; i.e., refine and extend the crude biological criteria now available for low-velocity, penetrating missiles.

8. Refine and extend the incomplete biomedical criteria for nonpenetrating missiles now based mostly on meager data dealing with blows to the head and thorax.

The Subcommittee, without further study, is unable to point out where funds allocated to biological research could best be spent under conditions where funds are limited. Calculational models for estimating survivors of nuclear weapons with reasonable realism, for use in analysis and design as well as statistical studies, constitute a priority need for OCD research. Accordingly, it is recommended that a calculational model similar to and more comprehensive than that developed under OCD Research Work Units 1614A and 1125A be completed and continuously updated and refined for the purpose of directing research funds toward those efforts where improvement in knowledge will make the greatest contribution in terms of a suitable indicator, such as a decrease in the number of casualties or an increase in the accuracy with which casualties can be predicted.

More detailed views on biological-response problems follow:

1. <u>Response to Loading from Ideal Wave Forms</u>.

   The main remaining problems in this area are to refine criteria applicable to man that are now tentative[6] and to solve the many interspecies scaling problems.[7]

2. <u>Response to Loading from Non-Ideal Wave Forms</u>.

   Some data on stepwise loading based on tests with small animals are available.[8,9] Work on large animals has now begun. Many more years of effort are needed. For

example, pressure-time patterns, including fast transients, should be made inside a variety of structures; this could involve computational work and observation. Also, there should be biomedical experiments, both theoretical and empirical, on animals to develop criteria applicable to humans.

3. Response to Missile Translations.

There are very crude and tentative biomedical criteria for some aspects of non-penetrating missiles.[6] There are considerable data and models for assessing vulnerability of the body for high-velocity fragments, but little for low-velocity.[10] Many years of work are needed in a systematic effort to develop the needed biomedical criteria.

4. Response to Whole-Body Translation.

Exploratory biomedical experiments on four species of small animals have defined impact-velocity/survival relationships.[11] Crude criteria have been estimated for man.[6] Experiments on large animals to allow better estimates of human tolerance for impact on hard surfaces have been programmed.

5. Response to Dust and Non-Line-of-Sight Thermal Burns.

The Nevada tests have shown interior dust to be a potential hazard that needs to be evaluated in terms of the effects associated with overpressure and structure.[12] The conditions under which casualty-producing dust occurs need to be defined; definition is also needed of the overpressure levels and thermal conditions which may contribute to non-line-of-sight burns, and dust is an important heat-transfer mechanism in these phenomena.

THERMAL EFFECTS

Our review, and resultant recommendations, of the OCD research program in the area of thermal effects is influenced by the knowledge that DASA is currently writing a thermal-effects source book. This source book will provide a careful summary of current knowledge of thermal effects of nuclear weapons. Those responsible for writing the source book should be requested to list serious gaps in our knowledge of these effects.

Further, the outline of the thermal chapter of DASA's new, uncompleted "effects manual," EM-1, indicates that most OCD problems will be considered. However, we do make several recommendations and observations in this area:

1. <u>Comparison of Calculated and Experimental Thermal Fields</u>.

   Treatment of various phenomena influencing nuclear-explosive, thermal-radiation exposure to be included in EM-1 will apparently rely heavily on calculation. A comparison of this work with nuclear test data is being done. This comparison should include, where possible, not merely the radiant exposure, but also time and spectrally resolved data.

2. <u>Atmospheric Transmissivity</u>.

   Thermal transmissivity of the atmosphere is highly variable and directly affects the thermal radiation that reaches a target. It is of special importance because of potentially large errors which can occur in prediction of thermal exposures at large distances from high-yield weapons. We have reservations concerning the state-of-knowledge of atmospheric transmissivity, and more work should be done in this area to reduce the uncertainties for large weapons at long range. However we make no recommendations for research until after publication of the DASA studies.

3. <u>Situational Factors</u>.

   Only limited theoretical work has been done on establishing techniques for estimating thermal fluxes in buildings and rooms as a function of position in the structure and in terms of thermal levels outside structure. These "situational factors" require attention and apparently will not be considered by DASA. They include the problems of thermal flux entering rooms and buildings through openings such as doors and windows, the shielding factor of buildings and trees, etc. Techniques should be further developed (a) for estimating probabilities of igniting fires within buildings, and (b) for analysing the effectiveness of NFSS shelters and open shelters for initial-effects protection.

4. <u>Fire-Start, Fire-Spread Characteristics of Materials</u>.

   Many groups, such as Underwriters Laboratory and the National Bureau of Standards and organizations in

other countries, routinely test the fire sensitivity of various materials. Results of these groups have been extremely varied,[13,14] e.g., their evaluations or ratings for a single material may extend from "most fire-sensitive" to "least fire-sensitive." These variations are caused by differences in test conditions and in the criteria used, which, in turn, result because the basic understanding of fire phenomena has not been developed. The present limited research program needs to be enlarged with a coordinated national program for the formulation of unambiguous test and evaluation criteria for combustible materials. This work will involve a study of the basic reactions which occur as a function of heat-input rates. "What is not clear is just which properties and phenomena are essential in building a fire."[13]

5. Rate of Fire Spread.

The Illinois Institute of Technology Research Institute (computerized)[15] and URS (non-computerized)[16] models are nearly completed. There still remains the need for better evaluation of fire spread by fire-brands, and for a method for taking into account the countermeasures of hardening, use of smoke-screens, and fire-fighting. Techniques for estimating fire spread are needed for damage and casualty estimates, and for determining capabilities of rescue operations and fire control.

6. Large Fires.

Fires which can occur as a result of nuclear detonations may involve simultaneous ignitions of larger areas than have previously been observed. In the past, some of the larger fires have had much more severe results than were predicted by extrapolating from small fires. There have been large-scale fire tests such as Flambeau,[17] but in order to determine new phenomena present in very large fires and how they produce casualties and damage, additional work is needed. Such work should include the theoretical treatment of fires of all sizes and the small-scale experimental modeling of very large fires. However, because large sums of money must be spent to conduct very large test fires, the Subcommittee urges extreme prudence in doing further very-large-scale experimental work. Further, the Subcommittee urges that the effects of the redistribution of fuel by the blast wave be considered in future work.

7. Fire/Fallout Interaction.

Civil-defense planning is based on fallout models which are, in turn, based on data that do not include consideration of fire effects on fallout, e.g., the influence of fire-induced convection columns on the pattern of fallout deposition. Small-scale wind-tunnel experiments have indicated that fire effects can cause a drastic change in fallout distribution -- moving fallout further downwind, thus increasing areas of involvement, but decreasing the levels of maximum intensity. URS is doing work in this area.

8. Fire/Blast Interaction.

Nuclear-weapon effects usually occur together but are studied separately, so little work has been done on interactions. The Forest Service did some work on blast extinguishment of fires in the open;[18] URS has taken a preliminary look at the effects of air blast on interior fires started by thermal-radiation exposure.[19] However, fire development and spread through blast-damaged areas, as well as blast-initiation of fires, has been scarcely studied. Work in the area of blast/fire interaction, now in a preliminary state, should be continued and extended.

9. Other Problems.

In addition to the above, there are two critical problems that demand further effort: life hazards in fire areas and protective measures against them.

BIOLOGICAL RESPONSE TO THERMAL EFFECTS

As in the case of blast, the most important area for research in thermal effects is in the biological sciences.

Thermal-Radiation Injury.

For civil-defense purposes, the objectives of research on thermal-radiation injuries should include the description and understanding of the burns that might be received by people in the open or in shelters where thermal radiation might enter. Data are needed on the size and location of areas burned by direct thermal radiation or by ignited hair or clothing; also needed is an understanding of burns received through clothing.

Another objective of research on thermal radiation injury is knowledge of how the severity of burns is affected by evasive actions by the victim; also by clothing factors, climate, the ambient temperature, and such personal factors as skin pigmentation, skin thickness, etc. The threshold of injury from burns to particularly sensitive areas, such as lips, nose, ears, eyelids, and fingers needs to be established.

Life Hazards in Fire Areas

As part of the casualty-assessment task it is necessary to estimate hazards outdoors from heated air, smoke and noxious gases, and from thermal radiation from heated walls and doors in shelters. Current knowledge, which is based on World War II fire-casualty data plus some results from tests of noxious gases and heat on mice, should be augmented with more investigations of the effects of smoke and noxious gases other than CO and CO_2.

An indirect effect requiring examination is that of the volatile products and fine particulates liberated by the thermal radiation in the open, or in shelters with openings where thermal radiation may enter. These volatiles may cause burns or be toxic and cause incapacity or death. The redistribution of these products by the subsequent air blast to unexposed areas and into shelters, and its consequent effect, should be investigated.

BIOLOGICAL RESPONSE TO COMBINED EFFECTS

Present estimates on casualties might be significantly changed if combined instead of separate injury criteria were available and used in determining casualty thresholds and consequent pathology for those significantly exposed to more than one effect. The synergisms involved in biological response to weapon effects are not well known. There has been some work on the effects of burns plus gamma-radiation exposure at the Naval Radiological Defense Laboratory,[20] and experiments with X-rays plus thermal exposure on dogs at the University of Virginia.[21] The Canadians have also studied combined thermal and ionizing radiation in pigs,[22] and in Sweden, overpressures and gamma-ray exposures have been combined on mice.[23] An area of considerable urgency is the effect of the combination of burn and mechanical injury, such as fractures, impact, and blood loss. Also, the influence of age, particularly for the young and very old, should be established. This should also be established for injuries from combined as well as individual effects.

Many more years of study and test using various animals would be required to mount a systematic attack on the problem of making meaningful estimates for man; required would be the formulation of biomedical criteria for assessing hazards from combined effects. Some work in the area of combined injuries is now under way at Lovelace Foundation under DASA support,[24,25] which supplements earlier but meager work in Albuquerque.

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A P P E N D I X IV.

R A D I A T I O N S H I E L D I N G

SUBCOMMITTEE MEMBERS

CHILTON, Dr. Arthur B. (Chairman through December 1968)
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EISENHAUER, Mr. Charles M. (Present Chairman)
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APPENDIX IV. RADIATION SHIELDING

Since its establishment in 1958, the Subcommittee on Radiation Shielding has devoted most of its time and effort to the details of the fallout-shielding program, particularly the research sponsored by the Office of Civil Defense (OCD) and its predecessors. Major subcommittee effort has thus gone into advice and assistance in the development of the engineering methodology[1] used in the National Fallout Shelter Survey (NFSS), and adapted for the Home Fallout Protection Survey (HFPS) program. The Subcommittee has also been much interested in the training programs sponsored by OCD that are designed to provide qualified architects and engineers for survey and design work. At the same time, it has been concerned with the problem of increasing the capacity of universities for providing a broad teaching base in fallout shielding.

The fallout-shielding area is notable for the amount of OCD effort, other than research, that has been devoted to it. As a result, work in the field has provided feedback to research, and has served as a spur and incentive. Accuracy of protection-factor calculations is one of the questions that has been raised for subcommittee consideration, primarily from the point of view of "What are the accuracy limits of the procedure?" "What inherent improvement is possible, and at what cost, etc.?"[2]

Another task stemming from questions coming from the field has been support for the HFPS. The Subcommittee has been concerned with the accuracy of the program as well as with the instruction material to be transmitted to homeowners on such matters as how to improve the fallout-protection capability in homes.[3]

The Subcommittee has also had a continuing interest in initial radiation. In contrast to the fallout-shielding area, OCD has had little operational need for information on initial radiation and how it can be shielded against, and OCD has not sponsored much research on those subjects. Recent Subcommittee activity has concentrated on the problem of developing a competence to provide an engineering technology for analyzing and designing structures to protect against initial radiation.

In connection with the accuracy problem, a question that has been repeatedly raised since 1959 concerns the capability of the technology for improvement. In February 1965, OCD requested answers to seven questions about the state of knowledge in fallout-shielding technology, particularly as to accuracy. Informal replies were made by the Subcommittee in June 1965 and again in August 1965; the formal answer was transmitted October 7, under the title: The Accuracy of Radiation Shielding Calculations, September 30, 1965. In transmitting them, the Subcommittee pointed out that answers to three of the questions (those dealing mostly with the effect of inaccuracies) were suggestions

on how answers could be obtained, rather than answers themselves. The Subcommittee also urged more research both to reduce probability of serious errors, and to "establish quantitatively how valid the predictions generally are." Four most urgent topics were cited: 1) research on in-and-down scattering; 2) recomputation of basic scattering data in the National Bureau of Standards Monograph No. 42; 3) study of source holdup in shrubbery and of movement of fallout material after deposition; and 4) research dealing with limited strips of contamination.

In 1967, the Subcommittee prepared but did not transmit a brief statement on the accuracy capability of the fallout-shielding methodology;[4] in 1968, it approved a correction factor for use in calculating the contribution of in-and-down scatter.[5]

SOFT SPOTS IN OCD PROGRAM

A soft spot is defined here as a weakness or gap in a program; it is an area, item, or segment of a program that needs corrective action. The soft spot might be in the methodology for predicting protection factors (PFs) as well as in some part of the research program.

The three major divisions into which the discussion of soft spots is divided are (1) accuracy achievable and desirable in PF calculations; (2) refinement of fallout-shielding methodology, and (3) development of initial-radiation-shielding methodology.

Accuracy Achievable and Desirable in PF Calculations.

The shielding research program supports a requirement for providing shelter spaces to maximize survivors of a nuclear attack. Federal Civil Defense Guide, Part A, Chapter 1, Appendix I, of December 1966, discusses the national policy for a minimum protection factor of 40 for public fallout shelters. The guide states that this policy is based on DOD studies of the effects on the U. S. of a large variety of hypothetical nuclear attacks; however, information on these attacks is scanty. We believe there should be available a careful, well documented, quantitative analysis of attack situations from which one should be able to show that a shielding methodology has to provide either relative or absolute protection factors for structures to an accuracy of some specified number.

In considering potential for accuracy of the Engineering Manual method, the Subcommittee, in October 1967, agreed on the following statement:[4]

> Starting with the known behavior of gamma rays from an infinite plane source in an infinite homogeneous medium, and building upon a logical, consistent set

of educated guesses, the barrier-geometry-factor methodology permits the calculation of protection factors provided by a very few basic geometrical shapes that are usefully similar to actual structures. Experimentation with various combinations of these simple shapes surrounded by plane sources, similar in energy to that of fallout, has shown that the methodology (as represented by PM-100-1*), with minor revisions, is capable of predicting protection factors of idealized structures within ±25 percent of the measured values. Much more limited experimentation with simulated fallout sources on an infinite, smooth plane around real and model structures indicates that the methodology is, or will soon be, capable of predicting protection factors within a probable error of about 30 percent (this means half the predictions would be this good or better) for actual structures having nominal protection factors of 100 or less, provided the structural configuration is accurately known and deviations of the surrounding field from an infinite, smooth plane are accurately defined, and provided effects due to ground roughness, foliar retention and weathering can be neglected without appreciable error.

As has been pointed out, the determination of the requirements for accuracy should be based on careful analyses of a variety of hypothetical enemy attacks. It appears that such a task is beyond the purview of the Subcommittee. However, the Subcommittee consensus is that there is a need for determining accuracy limits of calculational techniques (as in the current revision of the Engineering Manual), and for completing a cost-effectiveness study which analyzes the relationship between casualty rates and the accuracy of shielding analyses.

In Subcommittee meetings, it has been suggested that there should be a definitive examination of the state of the art in weapons shielding. The Subcommittee has also considered the proposal that a more accurate method than the one in the Engineering Manual[1] should be used, one which has been adapted to computers and is more complex and detailed. The Subcommittee has not taken a final position on the latter question pending a quantitative analysis showing the need for either greater accuracy or more versatility, etc. In this connection, there is possibly an additional need for a more thorough comparison between actual measurements of full-scale buildings, for which a great deal of data exists, and calculations made by the various accepted methods, PM 100-1 for example. This will give input to the accuracy question from a somewhat different direction than that described above.

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* See Reference No. 1.

To sum up, the Subcommittee views on these accuracy questions were that there were valid reasons -- in addition to increasing civil-defense effectiveness -- for trying to increase accuracy: 1) the achievement of a balanced design for fallout shelters; 2) more confidence and capability for calculating PFs; and 3) the attainment of an important step leading toward acceptable accuracy in calculating PFs in very complex real structures.

Subcommittee Review of Present Methodologies.

The Subcommittee made its examination of problem areas in the methodology for making PF calculations from the point of view of answering these three questions:

1. Is there a weakness?
2. Can it be removed by further study of available data?
3. Is it worth the effort?

These questions were first applied to the overall accuracy of protection-factor calculations. It was generally agreed that the answers would be (1) yes, there is weakness; (2) no, available data are inadequate to remove weaknesses; and (3) yes, some sort of effort, possibly including operations research, is warranted.

The questions were then applied to shielding methodologies for (1) fallout, and (2) initial radiations.

For the first, refinement of fallout-shielding methodology, the items or important elements that were evaluated as to their importance to the effectiveness of the methodology are these:

a. Ground roughness effect.
b. Foliar holdup.
c. Age of fallout -- spectrum.
d. Weathering.
e. Particle ingress.
f. In-and-down scattering.
g. Limited strips of contamination.
h. Heavy interior partitions.
i. In-and-up scattering.
j. Scaling.
k. Inhomogeneous barriers.

In discussing these items, and in forming conclusions about them, the Subcommittee lumped some together. These are the Subcommittee conclusions:

1. With regard to ground roughness, foliar holdup, weathering, and particle ingress, it was agreed that

there was a significant weakness; that to a large extent existing data could profitably be given additional study; and that the effort should be given a low priority. There was also agreement that there should be a high priority given to the related problems of developing techniques for making accurate predictions on fallout deposition in non-ideal situations and on subsequent motion of particles. Since this problem involves micrometeorology, a field not represented on the Subcommittee, it was felt that responsibility for considering it properly fell on the Fallout Subcommittee.

2. In the case of the fallout energy spectrum, it was agreed, that, since the errors appear to be conservative, this is not a serious problem and should get a low priority.

3. In-and-down, in-and-up scattering were considered to have methodology weaknesses. For both it was felt that further study of available data could solve the problem, and that the effort involved was worthwhile.* It was pointed out that the additional effort to carry out work on in-and-up scattering above and beyond that required for in-and-down work would probably not be large.

4. For limited strips of contamination, it was agreed that there was a weakness in the methodology; that available data were not entirely adequate for removing weaknesses through further study; and that the continuation of effort on experiment, as well as on theoretical work, at present levels seems warranted for another year or two.

5. In the case of interior partitions and complex structures, the Subcommittee consensus was that certain of the manual techniques represent weaknesses in the methodology -- the Subcommittee did not know whether other weaknesses existed; it was felt that further study would remove some and perhaps all of the weaknesses. The Subcommittee did not agree on whether or not effort beyond that required to review the problem and the available, pertinent data would be worthwhile.

6. For problems of scaling and of inhomogeneous barriers, it was agreed that these were weaknesses, that further study of available data would remove them, and that the effort involved was warranted.

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* Note that the Subcommittee has endorsed the use of the correction factor suggested by Mr. Eisenhauer as interim solution to the in-and-down problem.[5]

In the second case, development of initial-radiation-shielding methodology, the area should be treated in a logical step-wise fashion. The first need is for an analysis of attack situations indicating the levels of radiation, overpressure, etc., that could be expected. Second, the required neutron and gamma shielding factors consistent with protection against other effects should be determined. A cost-effectiveness study and accuracy-requirement calculation should follow. From these, one could proceed to a determination of available mechanisms for determining initial-radiation-shielding factors and whether they give the needed accuracy. Then a calculational and experimental program to get each parameter dependence to within needed accuracy could be developed.

In considering the initial-radiation-shielding problem, the Subcommittee further examined the area as it related to determining a priority order of research. No conclusions were drawn, but Subcommittee discussion brought out the following points:

1. There appears to be a question of whether or not initial-radiation research should follow techniques and objectives similar to those followed with fallout shielding. Similarly, there is a question of the priority between initial-radiation programs and efforts to refine fallout-shielding technology by redoing experiments, etc. The problem of how much experimentation can be done in initial radiation, with the limited facilities for doing it that now exist, is also pertinent. Finally, the responsibility of OCD and the Defense Atomic Support Agency (DASA) in the initial-radiation-research area are important to understand. So far, DASA has taken primary responsibility for initial-radiation research, but it is conceivable that OCD might become directly concerned when the problem of shielding analysis comes up.

2. Data on prompt gammas and neutrons appear to be the more difficult to supply of the prompt-effects information.

3. The behavior of neutrons in complex structures needs to be further investigated.

Areas of particular interest to OCD might include the following:

a. Effect of attack situation on initial-radiation-protection requirements.
b. Initial-radiation-attenuation requirement for balanced protection.
c. Accuracy required in PF determination.
d. Parameter-dependence determination.
e. Methodology or state-of-art evaluation for initial radiation.

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3. Fallout Protection for Homes with Basements. Office of Civil Defense, H-12, July 1966.

4. Minutes of the 26th Meeting of the ad hoc Subcommittee on Radiation Shielding, Advisory Committee on Civil Defense, National Academy of Sciences-National Research Council, October 25-27, 1967.

5. Minutes of the 28th Meeting of the ad hoc Subcommittee on Radiation Shielding, Advisory Committee on Civil Defense, National Academy of Sciences-National Research Council, October 9-11, 1968.

APPENDIX V.

DESIGN OF PROTECTIVE STRUCTURES

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APPENDIX V. DESIGN OF PROTECTIVE STRUCTURES

The difficulty in getting fully satisfactory results from the research program in the prompt-effects-protection area seems to stem primarily from lack of feedback from a vigorous operational program. In addition, reduced support for all civil-defense research has reduced effort in the prompt-effects area.[1]

This situation has engendered several comments by the Subcommittee:

1. Office of Civil Defense research management has a continuing obligation to convince decision-makers in the Department of Defense, in the rest of the executive branch, and in Congress of the need for prompt-effects protection.

2. There are serious technical gaps in our knowledge of how to evaluate and increase the prompt-effects protection in existing structures.

3. The principle of risk orientation should be adopted by administration leaders and Congress.

The Subcommittee, in considering shelter-design problems, made these points:

1. There is need to slant financing as well as design, e.g., to utilize tax inducements.

2. The relative desirability of family versus community shelter varies greatly according to a number of different situations. Also, dual-use shelter seems to be clearly preferable to single-use shelter from the practical point of view, although there are conditions when single-purpose shelters are needed, e.g., for high-psi protection.

3. While a planned, orderly approach to providing protection is more desirable during a long period of international tensions, much could be accomplished in providing shelter through crash programs and immediate improvisations; the availability of materials and tools would be critical.

ACTIONS RECOMMENDED BY THE SUBCOMMITTEE

The provision of moderate protection for people and resources should involve protection against initial radiation, thermal effects, blast (2-100 psi, including protection against structural failure, missiles, debris, and air and ground shock), fire, and fallout. The emphasis thus far in federally funded programs (excluding construction) has been in the area of fallout protection.

In view of the world situation and the possibility that nuclear weapons may be employed in wars in which this country is involved, we believe that the federal government has the responsibility for providing a long-range, planned-protection system for its people and resources to the extent possible. Any review of a credible nuclear-attack threat to this nation indicates that the population and industrial complexes would be subjected to a wide spectrum of nuclear-weapons effects. This spectrum varies from essentially no probability of initial radiation, blast or thermal effects, and little or no fallout or fire risk, to an overwhelming destruction in immediate target areas. The Subcommittee believes that the degree of protection provided should reflect these variations, in other words that some form of risk-oriented approach should be used to determine the type and protection level of shelters throughout the U. S. Application of this approach might be exemplified by:

1. No financial encouragement given in those areas where there is little risk from fallout or other effects.

2. For less than 2-psi-blast areas, and where dangerous levels of fallout are expected, the National Fallout Shelter Survey type of protection with some inexpensive upgrading would be suitable.

3. In areas where threat estimates would indicate blast over-pressures of over 2 psi are likely, the population would receive additional financial inducements to improve survival chances.

The most sensible prompt-effects shelter program would appear to consist of maximum use of dual-purpose shelters derived from slanting the designs of new construction, the use of existing structures with modifications, and the construction of single-purpose shelters. This latter should be a continuing program of construction over an extended period of time with its objectives constantly reviewed so that they reflect the best currently available knowledge and estimates. There should be provision for implementing short-term programs in the event of a national crisis during initial construction; planning for them

should be included. The development of such a program implies a national priority of some level, with full concurrence by the Department of Defense, Congress, and other directly involved agencies and groups. The national shelter program must relate to other national defense efforts such as those involving offensive and defensive weapons procurement and deployment, surveillance and communications systems, decentralization of population and industry, and stockpiling, distribution, and protection of resources required for survival and recovery.

DISCUSSION

The ability to provide the criteria and guidance for construction of the desired physical protection systems contemplated has been available, at least in a form to permit a "go ahead" on a pilot program, for some time. The basis for providing such protection has evolved from the results of atmospheric tests made at the nuclear-test sites between the years 1951-57 for structures loaded in the 2 to 100-psi-overpressure range and from numerous theoretical and laboratory research studies that have been and are being conducted. It is recognized that the early field tests were conducted with low-yield (kiloton) weapons of relatively short pressure-pulse duration; nonetheless sufficient knowledge exists to permit criteria to be developed for design of single-purpose shelter against long-duration (megaton) weapons. The past studies and tests have involved consideration of domestic and foreign protection systems, and at one point in time a number of standard designs were available for interested parties.[2-4] Even though there is a definite need for continued research in nuclear-weapons effects and protective systems, it is believed that theoretical concepts and basic data are generally available to permit development of criteria for the design of protection systems against initial effects in the ranges of interest. However, the development of such criteria will require considerable effort. It is interesting to note that in the late 1940s and 1950s, federal civil-defense programs involved consideration of all effects recognized to be of importance at that time. Subsequently, with the emphasis put solely on fallout, education and training concerning other effects was minimized, and the research was limited. In recent years there has been a modest resurgence of effort with respect to the entire initial-effects area. For implementation of long-range programs, as well as for meeting immediate crises, it is imperative to have available the design criteria which would permit development (new construction, remodeling, improvision) of protection. This aspect should have high priority within the OCD research program.

From the physical-implementation point of view, the development of a long-range program should be based on a risk-oriented approach[5] and keyed to the national commitment in terms of acceptance and funding.

It appears that the more promising program might initially start with programs involving federal financing and encompass dual-use concepts. Moreover, it appears that such a program will not go ahead without some incentive on the part of the government to provide such protection, either through direct incentive subsidy, tax advantage, or some other such means. Alternatively, legal requirements could be developed as has been the case in some northern European countries,* to insure that a reasonable level of protection is incorporated in new constructions. Even in this case, some basis for sharing, or providing for, the imposed excess cost must be implemented.

Implementation of such a program also will involve casting the criteria, and the design and analysis procedures, in a form which will lead to the most usefulness. State-of-the-art documents and comprehensive design guides should be prepared and distributed. There must be a concerted effort to provide long-term and continuous education for those persons who will be responsible for carrying out the design, installation and maintenance of such systems. At the same time, there should be available to the public a handbook describing the purpose, plans, and survival procedures to be followed in the event of a national emergency; this document could provide information on natural disasters as well as man-induced effects. Advantage should be taken of standardization of construction insofar as possible, and additional consideration needs to be given to the matter of habitability.

While the long-term plan is being carried forward, planning and documentation should be carried out concurrently to provide the populace with as much guidance as possible for short-time implementation of protection (days to a few months) in the event of a crisis prior to the completion of a long-planned program, and for the use of those individuals who may not be covered by the long-term protection programs.

This phase of the protection program, involving physical facilities, can only be successful if there is concerted planning and implementation of programs in other areas involving such items as the maintenance and operation of shelters, provisioning of shelters, maintenance of law and order, and a host of other items including a well-planned approach to postattack recovery.

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* See Appendix I.

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APPENDIX VI.

DAMAGE

LIMITING

SYSTEMS STUDIES

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APPENDIX VI. DAMAGE LIMITING SYSTEMS STUDIES

In the brief period since its establishment, the Subcommittee on Damage Limiting Systems has devoted most of its attention to briefings on and discussions of recent studies of hypothetical attacks. Of particular interest were the assumptions used in the studies concerning enemy attack objectives and tactics.

Some ten of the studies which were considered to be most pertinent to civil defense were examined and are the basis for a display chart which attempts to emphasize similarities, dissimilarities, and gaps among and in the assumptions and other characteristics of the studies. The display is classified SECRET and is an annex to this Appendix.

The damage-limiting studies that were the basis for the display are as follows:

1. Defense of Cities Against Ballistic Missiles (U), Department of the Air Force, 1963 (Secret).

2. Nike-X Threat Analysis Study for Secretary of Defense (U), Vol. I: Summary...Vol. 10: Range of Civil Defense Postures and Interactions with BMD. Nike-X Office, 1964 (Secret).

3. The Damage Limiting Potential of Civil Defense Programs (DAL-65) (U), Office of Civil Defense, 1965 (Secret).

4. Nike-X Deployment Study (DEPEX) (U), Appendix F: Interaction of BMD with other Active Defense Programs and Civil Defense. Department of the Army, 1965 (Secret).

5. Population Damage from High Altitude Nuclear Bursts Over Urban Areas (U), Stanford Research Institute, September 1963 (Confidential).

6. Light Attack Shelter Requirements and Defense Avoidance Fallout Tactics (U), Stanford Research Institute, July 1966 (Secret).

7. Protection Against Standoff Thermal Attacks (U), Stanford Research Institute, January 1967 (Secret).

8. Civil Defense Interactions with Ballistic Missile Defense (U), Stanford Research Institute, April 1967 (Secret).

9. Postattack Viability of the United States--1975 (U), Department of the Army, January 1967 (Secret).

10. Complementary Aspects of Civil Defense with Sentinel System (DAL-67) (U), Office of Civil Defense, 1967 (Secret).

The assumptions that were compared and displayed include: yields of individual weapon, total attack yield, type of burst, attack objectives, ABM deployment and effectiveness, civil-defense posture, etc. The type of study and the form of the output have also been included. The display has been so designed that each of these items can be described by one of three symbols standing for "yes," "no," and "insufficient data."

The following is an unclassified example of the display:

Civil Defense Posture	A Study	B Study	C Study
NFSS*	x	x	x
Full Fallout Protection	?	x	
~ 3 to 30 psi Protection			x
> ~ 30 psi Protection	x		

Key

$\boxed{x}$	= yes
$\boxed{}$	= no
$\boxed{?}$	= insufficient data

In the display a "yes" answer can be applied to more than one subdivision.

Obviously, firm conclusions cannot be drawn from this display chart until all pertinent studies have been examined, and until the assumptions and other characteristics of studies in process are similarly reflected. However, the Subcommittee believes that the conclusions listed here, although still preliminary, are firm enough to submit as indicators of where gaps or weak spots in coverage now may exist. The conclusions are:

1. Current studies give results in number of casualties and in fractions of industrial and other national capabilities destroyed. Attack studies should include more details on the postattack-recovery process, particularly the step by step interaction

* National Fallout Shelter Survey.

between elements of that process, thereby providing better measures of the relative effectiveness of various options for preattack civil-defense planning and action, and for defining the "state-of-the-nation" as a function of time following an attack.

2. Attack studies should examine the consequences of attacks that are specifically designed to make national recovery difficult, including attacks that concentrate on producing both short- and long-term bottlenecks in key national capabilities.

3. There should be considerably more attention given to the consequences of protracted nuclear attacks, as opposed to single attacks that are made within a few hours or days. The relative effectiveness of various passive and active defense measures is likely to depend on whether or not an initial attack is followed by continuing attacks that extend over months or perhaps years following the initial attack.

4. Account should be taken of possible changes in the nature of the attacks that follow the initial attack, in which the attacker shifts from emphasis on one method of attack to another, as key components of active defensive systems are destroyed. An initial attack by missiles may be followed by heavy-bomber attacks, for example, if the attacker determines that bomber defenses have been destroyed.

5. Detailed postattack-recovery studies should take into account the relatively long-range effects of nuclear explosions, such as the effects of fallout on food supplies, the changes in the state of ecological balance due to forest fires and radiation damage to plant and animal life, etc.

6. The premise that nuclear attacks on the United States are much more likely than attacks that use chemical or biological warfare (CBW) agents is the current basis for planning. Attack studies that include the use of CBW agents should be made to help determine whether that premise remains valid, particularly with respect to the postattack-recovery process.

7. Nuclear-attack studies should take the effect of warning into account in more detail than in the past. The types and timing, relative to the onset of an attack, of assured warning to the population and to

military and civil-defense authorities, can have major effects on the extent of shelter occupancy at the time of the attack, and the types of protective action that can be taken, including limited or extensive evacuation of urban areas, use of miscellaneous types of "shelters of opportunity," such as ditches, natural depressions in terrain, and building foundations, and taking rudimentary measures to decrease the vulnerability to thermal effects, etc.

8. Detailed studies of the postattack-recovery process must distinguish between short-term and long-term efforts to treat people who have been injured.

9. Further studies of the coupling between active-and passive-defense measures, with particular attention given to the postattack-recovery process, should be made with account taken of the specific proposed deployment of the Safeguard ABM system.

10. In many attack studies, all prompt effects are lumped together and characterized, for example, by overpressure levels, often resulting in gross errors in the prediction of casualties or levels of damage to buildings and their contents. The relative importance of each of the different prompt effects which is also generally dependent on the yield of the explosion, should be taken into specific account.

11. Further work is needed to determine the sensitivity of the results of attack studies to assumptions about the character of defense preplanning, particularly with respect to methods for management of civil-defense operations during and immediately after an attack, during periods of postattack recovery, and during various stages of a protracted set of nuclear attacks.

12. The increase in shelter occupancy that might be rendered possible by use of an ABM system having an initially high effectiveness in destroying warheads that are targeted for cities should receive more attention. In some cases such ABM protection may increase the time available for people to take shelter from a practically negligible time to sufficient time for most of the city's population to take shelter.

Although not directly applicable to attack studies and the display chart, there are two comments that bear on the whole problem of civil defense and its environment:

1. The current national lack of interest in civil defense and an apparent confidence in deterrence ignores the possible severe consequences of the development of such a great disparity in the level of damage between an attack on the U. S. and a counterattack by the U. S. that the Soviet Union or China could adopt measures, short of a nuclear war, that are strongly inimical to the security of the U. S. or our allies. In particular, if Soviet offensive and defensive preparatory actions should be allowed to reach such levels that postattack recovery could become qualitatively more effective and rapid in the Soviet Union, the U. S. could be blackmailed into inaction following major military (but non-nuclear) aggressive action by the Soviet Union, by a display by the Soviet Union of drastically more severe consequences to us than to them of a full-scale nuclear exchange.

2. The cost-effectiveness of civil defense compared to active-defense measures, or maintenance of an "assured destruction" capability, should be examined in a way that takes into account the persistence of the value of shelters and other civil-defense measures, compared to the gradual erosion of the effectiveness of each new military system that is developed. The cost of shelters, for example, should be compared with the integrated costs of new military systems that are developed by both sides in an arms race. In most important contexts, shelters built 20 years ago are just as good now as then; offensive missiles or defensive systems are not.

APPENDIX VII.

FALLOUT

PHENOMENOLOGY

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APPENDIX VII. FALLOUT PHENOMENOLOGY

The views of the Subcommittee on Fallout are presented in four parts, as follows:

1. The Radioactive Particle Population, covered under four headings: a) Radionuclide Distribution, b) Specific Abundance of Individual Radionuclides, c) Physical Characteristics of the Particle Population, and d) Additional Information Needed.

2. Fallout Prediction.

3. Long-term Aspects of Local Fallout.

4. Long-range Delayed Fallout.

THE RADIOACTIVE PARTICLE POPULATION

We are specifically concerned with the radioactive particles produced by high-yield nuclear detonations occurring at or near a land surface. The available experimental data[1,2,3] relating to the particles produced by such events are limited by the fact that only a small number of high-yield land-surface detonations have occurred and the better documented of these have been in a coral-island environment. Such data, supplemented by information obtained from one low-yield silicate-soil detonation,[4] have been used to arrive at the following generalized description of radioactive particle populations for land-surface detonations.

Radionuclide Distribution.

With the exception of tritium, carbon-14, and the long-lived rare-gas isotopes, all radionuclides formed are essentially removed from the vapor state and carried by particles. This conclusion is based on early-time gas sampling of the radioactive cloud. The radionuclides carried by the particles can be divided into two classes: refractory and volatile. A refractory radionuclide is one whose chemical state at time of formation is such that it (or its parent) exhibits a very low vapor pressure over local soil particles at their melting point. The refractory isotopes condense at early times and exhibit relatively invariant inter-isotopic atom ratios throughout the entire particle population, although some exceptions, not yet completely explained, have been noted.[5] The remaining radionuclides are designated as volatiles. The volatility may

be an inherent feature of the chemical species or it may be due to a rare-gas precursor. A more detailed analysis suggests that a third class of semi-volatiles is needed for an adequate description in some cases. The interisotopic atom ratios of volatile species, both one to another and to refractory species, is observed to vary from sample to sample through the particle population. However, it is possible to represent the variation in composition of all isotopes fairly satisfactorily in terms of the variation of two: a refractory species and a volatile species.

Specific Abundance of Individual Radionuclides.

The average specific abundance of a nuclide (zero-time atoms of radionuclide per unit particulate mass) is approximately proportional to the number of radionuclide atoms produced per kiloton of total device yield. This implies that the overall mass of the particle population depends only on the total yield of the device. In general the variation in specific abundance of individual radionuclides with particle size is quite similar from event to event. Thus, although both refractory and volatile radionuclides are found to some extent in each size class of particles, the refractories are enriched in the larger particles and appear to be mostly volume distributed while the volatiles are mostly surface distributed, particularly in the smaller sizes. Therefore the ratio of volatile to refractory radionuclides varies sharply with particle size in accord with the surface-to-volume ratio.

Physical Characteristics of the Particle Population.

The overall size range of radioactive particles produced by land-surface detonations appears to be from less than a few tenths of a micron to several thousand microns particle diameter. For the most part, the particles are irregular in shape, although in each population it is possible to find spherical particles which appear to have a composition like that of the environmental soil, and which exhibit high specific abundance of the refractory radionuclides. Many but not all of the irregular particles exhibit evidence of surface melting and hence were presumably injected into the fireball at an early time.

The detailed size distribution of the particle population is not well known. In general, the necessary combination of early-time cloud and local-fallout samples were not subjected to the size analysis needed to characterize the whole population. However differential analysis of historical samples of the cloud seem to indicate that the overall mass population is probably bimodal,[1,3,4] with one component exhibiting a peak in the 100-micron range corresponding to early injection and a second component exhibiting a peak in the five-micron range corresponding to late injection; the ratio of the total mass of component one to that of

component two is like ten to one. Recent two-dimensional hydrodynamic code calculation of detailed mass movements at earliest time appear to confirm such a two-stage injection.[6] Calculations for a 1-MT surface burst showed an initial injection of crater material into the fireball in times like a few seconds; this was followed by a late injection of surrounding surface soil brought into the condensing plasma by the entrained air.

Additional Information Needed.

Although the foregoing general description of the radioactive-particle population represents a significant advance in understanding, it still falls short of the detailed theory which is necessary to provide an improved predictive capability. Some additional insight may be gained from further re-examination of particulate samples from the limited number of past tests. However, it would seem more likely that improvement in the state of knowledge may be achieved through extensive application of theoretical and experimental approaches. Specifically, there are three areas in which these approaches appear to be promising:

1. Additional two-dimensional hydrodynamic studies of the time-temperature history of the particulate mass and radioactive plasma produced by high-yield detonations.

2. Studies of the shock production of particle population from nonparticulate source material.

3. Studies of mechanisms of capture of radioactive species by particulate material at high temperature, and of diffusion, condensation and coagulation processes.

At the present time only a very modest amount of research is going on in these essential areas. Furthermore, appropriately directed studies in these areas could provide answers to specific civil-defense problems of how the particle population would change with (1) height of burst, and (2) nature of underlying terrain.

FALLOUT PREDICTION

In civil-defense applications, fallout-prediction procedures may serve two general purposes: a) the provision of inputs to assessments and general evaluations of the fallout threat and to associated civil-defense countermeasures for assumed nuclear-war situations, and b) the early prediction of fallout hazards during a nuclear war.

The essential feature of fallout prediction models is the tracing of the path of a representative group of fallout particles from the time of detonation until they reach the ground. Once the ground location of fallout particles is mapped, as a function of size, the information on the distribution of activity with size as discussed in the preceding sections can be utilized to produce a measure of the hazard. The particles are carried aloft by the explosion and are brought back to earth by gravity. During their fall, they are transported and dispersed by winds and turbulence. Although winds carry the particles during the rise phase, and the heavier particles do resist the vertical patterns created by the rising cloud, the rise phase is dominated by the motion generated by the blast, and the transport phase is dominated by the ambient meteorological conditions.

The vertical velocity of the fallout particles will be determined in part by gravitational force and in part by the vertical air motions from convective activity or the vertical component of turbulence. Small particles (less than ten microns) will be greatly affected by this vertical turbulence; some are carried down faster, and some are held aloft longer than would be the case with gravitational settling alone. Particles larger than about 200 microns in diameter are little affected by average vertical motions and the fall time predicted on the basis of gravitational settling is a good approximation. For intermediate particle sizes, the influence of vertical motions may be appreciable at times. For megaton-yield explosions, 24 hours represents the upper limit of the time that a model based on gravitational settling rates can be expected to give reliable results.[7] Since 24 hours is also a time period for which reasonably accurate wind forecasts can be made, it represents a practical limit for forecasting the location and intensity of fallout. The significant "local fallout," as opposed to "world-wide fallout," is generally deposited in 24 hours or less.

In order to properly delineate a fallout field, it is necessary to compute the paths of different-sized particles falling from many different heights. An ideal way to do particle tracing is to utilize the presently available mathematical models for weather forecasting.* If the particles are placed in this model as the forecast is being made, at each time-step it is possible to find by interpolation the winds at the position that each particle has reached until each particle is traced to the ground. A forecast scheme such as this has been shown to

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* The Weather Bureau, the Air Force, the Navy, DASA, and the Lawrence Radiation Laboratory are included among those that have operational multilayer-meteorological-prediction programs which could be used to compute 3-D particle trajectories. Also, a feasibility test was run at RAND on a two-layer model.

have useful accuracy for periods up to 24 hours, so that one could have reasonable confidence in the prediction of the particle positions for that period of time. We conclude that the optimum way to predict the transport of particles from a nuclear detonation would be to use some form of numerical weather prediction which incorporates a method for tracing particles.*

Despite the good predictions of numerical weather forecasts, any fallout model will be plagued by a host of uncertainties in the transport and deposition of particles. There is, at present, no adequate method for treating turbulence. There is no way of including the effect of the local wind system. Furthermore, variation in the shape and density of the fallout particles will cause variation in their fall rates. To these factors one must add the possibility of (1) the attachment of small particles to larger ones; (2) the entrainment of small particles in the turbulent wake of large ones; (3) the mass subsidence of air which is heavily weighted by a large number of particles; and (4) precipitation-scavenging of debris particles. The observed dispersion of particle sizes at points of the fallout field is always much larger than that calculated by terminal-velocity considerations. Some of the above possibilities must be invoked to explain this dispersion, and further work is needed.

Despite the fact that there is still much to be learned about the whole process of radioactive fallout, we know enough about it to make a useful prognosis in time of emergency, i.e., we are able, before the fact, to outline those regions where the probability of heavy fallout is the highest, and those regions where there is high probability of little or no fallout. Granted, we do not know precisely. The OCD might well invest a small portion of their research money in the necessary work at relatively low priority to improve existing early-prediction techniques.

In fallout prediction, computations involving estimates of potential exposure dose, of the fallout-arrival time, of the fallout-deposit rate, and of the total activity deposited at a point are required. These estimates, in turn, require some specification of the size and shape of the initial particle cloud as well as of the concentration of the particles within the cloud, of the distribution of the radionuclides among the particles, and of the variation of these concentrations with space within the visible cloud volume. While some of these initial-condition factors are not considered here, all of them either serve as inputs to, or must be accounted for in some manner to expedite, exposure-dose calculations; several of these factors are required for estimating only

* The ESSA Research Laboratories have developed and tested such a fallout forecast scheme for the Office of Civil Defense (OCD). It is described in a Weather Bureau bulletin dated September 18, 1966, titled "The Guide to Fallout Areas Facsimile Transmission."

relative exposure-rate levels at given location. Previous studies indicate that moderate changes in cloud size and shape and in the distribution of radionuclides among the particles do not result in large changes in calculated fallout patterns. Less attention has been given to the initial spatial distribution of particles and radionuclides within the cloud volume and this area should receive further attention.

If the fallout-prediction system includes exposure doses to a variety of biological species, then the technical areas of interest are considerably expanded; some of these areas are: (1) retention of fallout particles by paved areas and roofs, (2) retention of fallout particles by vegetation, (3) movement of particles by wind and rain, and (4) solubility and radionuclide assimilation. While each area has been subjected to investigation in the past, the practical aspects of deposition dynamics in urban areas and the likely fate of fallout particles and of the radionuclides over time are not well known except perhaps in a qualitative sense because the parameters involved for quantitative assessment are many. Selective studies, derived from qualitative knowledge, could substantially improve current information (this direction appears to correspond with current OCD policy); statistical treatments of localized meteorological factors should be considered. Special problems, such as the effect of mass fires on the deposition of fallout, should be investigated.

LONG-TERM ASPECTS OF LOCAL FALLOUT

Since direct evidence is not available, the long-term effects of local fallout deposited on an extended land area are not well known. The major effects of weather (wind and rain) in redistributing the fallout particles initially deposited on roofs and paved areas in urban areas and on plant foliage in rural areas would take place in a matter of days and thus the fallout-particle redistribution process should not be considered as a long-term aspect of local fallout. A few past studies[8-14] suggest that perhaps the major long-term effects of local fallout are the second order consequences of radiation damage to the biological species (of all kinds) that receive relatively high exposure doses from gamma radiation, and in certain cases, additional high absorbed doses from beta radiation.

For humans and other higher forms of life, exposure to sublethal doses of gamma radiation would be the major cause of genetic damage to succeeding generations wherein the accumulated occurrence frequency of defects is assumed to be proportional to the total exposure dose. Other long-term human responses to sublethal external exposures and to the ingestion of specific soluble radionuclides in fallout include leukemia, bone tumors, sterility, cataracts, shortening of life span, and deterioration of the thyroid (the latter often expressed as a result of iodine uptake at early times from milk or water sources or inhalation). While methods for making gross estimates of the incidences of these consequences are available, their reliability is uncertain and could probably be significantly improved by further research efforts.

For plant ecosystems, both external gamma and beta doses could result in death of all plant life in some areas of limited extent, and in death to the more radiosensitive species in other areas; they could have no apparent effect whatever in a band around the borders of the 24-hour local-fallout areas. For many plants, the beta doses to meristematic tissues from fallout particles lodged on the foliage would be the predominant source of radiobiological effects which would include reduction in crop yields and other side effects where lethal exposures do not occur.

Available studies[8,9,15] indicate that the mere presence of local fallout over a large region would seldom, if ever, be a constraining factor in the cropping of agricultural lands beyond a year or so after nuclear attack.* The recovery of disturbed natural ecosystems without assistance from man, however, is expected to take a much longer time -- more than a decade, if the disturbance is severe. In some of these areas where the land is completely denuded of vegetation for a period of time, the land would be liable to erosion, and continued erosion could then result in a loss of the soil layer that is required to support vegetation growth. Detailed studies of these effects have not been made; brief survey-type reviews suggest that such effects might be limited to specific geographical regions of the country and to certain times of the year depending on the rainfall pattern.

Another semi-long-term aspect is the uptake of soluble radionuclides by food-crop plants from the soil and the entry of these elements into animal and human food chains; however, available studies[8,9,13,15-18] show that the contribution of these radioactive sources to the total doses of humans and animals under current protection systems would be relatively insignificant. The iodine-131 contamination of milk is essentially a short-term aspect which has been and is still being given considerable attention in the OCD research program. As a possible hazard to infants, its effect would come about only by way of pastured dairy cows. For fallout arrival times much less than 24 hours the survival of the cows would be in question and for arrival times much greater than 24 hours, iodine-131 levels in milk from healthy cows on pasture would be greatly reduced. The cause of the longer-term effect on children's thyroids noted recently[19] for the Marshallese has not yet been determined. Note that superposition of fallout from several bursts would extend the area and give later fallout arrival times greater importance.

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* The studies conclude that all the land needed to grow sufficient food for the surviving population should be used regardless of contamination. If not so needed, land heavily exposed to gamma radiation might be temporarily abandoned for a season or two; gamma exposure, rather than exposure from Sr-90, would be the predominant hazard to agricultural activity. Present contamination standards would be impossible to maintain in areas subjected to heavy fallout from nuclear attack, particularly with regard to ingestion effects which would be of minor importance to survival, as compared to effects of gamma-radiation exposure.

The longer-lived radionuclides that would be expected to enter the food chains from the soil and water in largest amounts are the fission products strontium-90 and cesium-137. These would be major components of long-range delayed, or worldwide, fallout. Due to fractionation, these nuclides are more likely to be in the worldwide fallout, and thus more likely to be spread over the landscape more uniformly than is the case with all nuclides taken together in the local fallout. This means that local concentrations of strontium-90 and cesium-137 tend to be less intense than the average for local fallout.

The hazards from these radionuclides in relation to other nuclear-war effects are often considered in assessing civil-defense problems. These studies should continue so that specific problems, if any, may be identified and so that the relative importance of the hazards from these radionuclides can be more adequately evaluated.

While general agreement exists on the topical content given above for the long-term aspects of local fallout, disagreement probably can be found with any one or all of the semi-conclusive or definitive statements made. In some sense, a wealth of applicable but scattered data exists that bears on the various long-term aspects;[20] at the current stage of technical development, useful progress could be gained by organizing the information and completing the logic for its application to better define the content of the problem.

LONG-RANGE DELAYED FALLOUT

The world-wide fallout occurring over periods of weeks to years following a nuclear detonation has been studied extensively in recent years, mainly under sponsorship of the U. S. Atomic Energy Commission and the Defense Atomic Support Agency of the Department of Defense.[21] Only in rare cases has the long-range delayed fallout been considered in civil-defense studies, and only then in reference to the long-term contamination of foodstuffs. Some of the older civil-defense public information pamphlets, especially those dealing with agricultural problems and food and water contamination, contained information on problems that were incorrectly associated with local fallout rather than long-range delayed fallout; this discrepancy does not occur in the newer pamphlets and public information on civil defense. The long-range delayed-fallout problem has not been considered to be a major problem of concern for the Office of Civil Defense. The two major factors involved in this lack of concern are: 1) the deposition occurs gradually over a number of months or years, and 2) the hazards to humans are insignificant relative to those from local fallout and other immediate or early-time effects. Thus, except for application of information developed for other agencies to establish boundary conditions for the relative degree of hazard, no effort on this subject by the Office of Civil Defense could be justified.

Perhaps a fourth to about a half of the total radionuclides produced in large-yield surface detonations and almost all those produced in airbursts, would be classed as world-wide fallout. Some investigators specify a third category of fallout, intermediate fallout, which is that deposited in the period of days to a week from tropospheric altitudes; for lower-yield weapons, this tropospheric component will predominate. Fallout from stratospheric altitudes is concentrated in the mid-latitudes (25° to 50° North or South, depending on whether the burst was in the northern or southern hemisphere.) Rainfall is a major mechanism for bringing the fallout to earth once it enters the troposphere; thus, deposit levels at a given place are somewhat proportional to the annual rainfall. The highest concentrations or most rapid deposition rate occurs during the spring months.

Currently available empirical models of the deposition process for the stratospheric component of the long-range fallout are sufficient for evaluating the relative radiological hazards applicable to civil-defense operations. Because of the delay involved, actual measurements of the accumulation of radionuclides such as strontium-90 and cesium-137 could be made in postwar situations to determine the hazard levels and to instigate counteractions if needed. Currently available research results generally support the conclusion that the hazards from long-range delayed fallout that could result from fairly massive nuclear exchanges within the immediate future would be insignificant relative to other hazards up to at least a year after such exchanges.

Although no acute problems associated with world-wide fallout have been identified, it would directly contaminate food crops and cause very complex ecological problems for several years after a nuclear war. Furthermore, delayed fallout could be as much as twice as big a fraction of the total fallout as is currently assumed; also, additional protection for the population against local fallout would increase the relative importance of the delayed hazard. In view of the uncertainties connected with this problem, frequent reevaluations should be made of the importance of countermeasures against the delayed-fallout hazard.

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